

















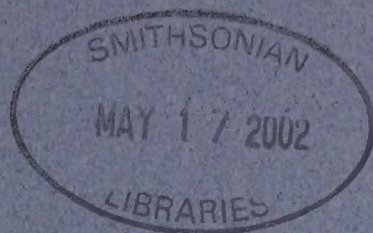








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# JOURNAL OF THE LEPIDOPTERISTS' SOCIETY

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## LIFE HISTORY AND IMMATURE STAGES OF *CATOCALA ATOCALA* (NOCTUIDAE)

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**ABSTRACT.** The immature stages of *Catocala atocala* are described and illustrated for the first time. Notes on the biology of the adults and larval foodplants are provided.

**Additional key words:** underwing moths, Louisiana, Mississippi, nutmeg hickory, *Carya* (Section *Apocarya*) *myristicaeformis*.

*Catocala atocala* Brou (1985) was recognized only recently as a separate species, having been treated in the literature as a variant of *C. agrippina* Strecker ever since Strecker (1874) provided the first illustration. Such late recognition of a new Nearctic underwing species is unusual given the longstanding interest in the genus, and the existence of several dozen 19th and early 20th century specimens of both sexes of *C. atocala* in institutional collections in North America and Europe (Brou 1985:889 mistakenly believed he had collected the first known females in the 1970's). Ironically, more than 50 years ago the Palearctic lepidopterist E. A. Dadd understood that *C. atocala* was a separate species, as he prominently labeled a male and female in a series of five *C. atocala* ex Boll collection at the Museum für Naturkunde (Berlin) as the types of "*Catabapta torfrida* Dadd." However, to our knowledge, the name was never published.

We are not aware of any previously published information on the life history of *Catocala atocala* other than Gall's (1991) speculation that, based on the external morphology and wing pattern of the adults, the foodplant would likely prove to be "pecan hickories" (*Carya* Nutt. Section *Apocarya* DC.) rather than "hickories" sensu strictu (*Carya* Section *Eucarya* DC.)

(Juglandaceae). Here we report on the successful rearing of *C. atocala* from ova deposited by wild-caught females, present field observations of adults in Louisiana and Mississippi, and suggest a probable natural larval foodplant for this species.

### DISTRIBUTIONAL AND BIOLOGICAL NOTES

In June 1999, LFG and JWP traveled to Louisiana and Mississippi to search for *C. atocala* and elucidate its biology. At the time, the only lepidopterist with significant firsthand knowledge of the species was its describer, Vernon Brou. His type series of 35 specimens was collected between 1975 and 1983. Among those specimens, 32 were taken at Edgard, St. John the Baptist Parish, Louisiana, two were from Weyanoke, West Feliciana Parish, Louisiana, and one was from Mississippi State, Oktibbeha County, Mississippi. Brou (in litt., June 1999) described the type locality as follows: "The Edgard . . . location I lived on and collected for about 14 years is not easily accessible. I . . . haven't been back there for about 15 years, and I'm sure it is nearly impossible [now] to get to the pecan tree area . . . this area is primarily agriculture (sugar cane), private property, or mostly impenetrable swamp requiring a pirogue (boat)." The few specimens of *C. atocala* cap-



tured in Tennessee, Arkansas, Illinois, and Oklahoma since the 1985 description all came from habitats apparently comparable to the type locality—low-lying regions within approximately 30 km of either the Mississippi River or a major river that drains into it (Brou's Weyanoke locality was nominally in upland woodlands, but nevertheless, quite close to the Mississippi River).

Based on this information, we opted to begin searching in the broad vicinity of Weyanoke, Louisiana, making transects using local roads that ran largely perpendicular to the Mississippi River, on the assumption that the moth's primary habitat was not upland woodlands per se. On the first transect run on 28 June 1999, JWP found a number of adult *C. atocala* just east of the Mississippi River near Saint Francisville, Louisiana. Our further exploration of the Saint Francisville area on 29–30 June 1999 revealed that adult *C. atocala* appeared to occur only in shaded woodlands in and around the floodplains immediately adjacent to the Mississippi River. We successfully applied this search protocol on 1–2 July 1999 as we drove north along the western border of Mississippi, ultimately finding adult *C. atocala* in the following six parishes and counties: off State Route 10, 1 km S of Saint Francisville, West Feliciana Parish, Louisiana; off Carthage Point Road, 4 km W of Carthage, Adams County, Mississippi; 4 km NW of Magna Vista, Issaquena County, Mississippi; 5.5 km W of Deeson, Bolivar County, Mississippi; 8 km WSW of Friar's Point, Coahoma County, Mississippi; west of Sam's Town Casino, 12.5 km W of Robinsonville, Tunica County, Mississippi. Despite an extended search on 2 July 1999, we failed to locate adult *C. atocala* W of Walls in DeSoto County, Mississippi (in that area, on the outskirts of Memphis, Tennessee, the appropriate habitat appeared significantly more fragmented and less dense than in all counties to the south; but note the prior capture of *C. atocala* by M. Furr in Meeman Shelby State Forest, Shelby County, Tennessee). On 3–5 July 1999, JRS visited the Saint Francisville locality and made further observations on *C. atocala* adults.

The preferred habitat of *C. atocala* in Louisiana and Mississippi appears to be shaded, moist woodlands in lowland floodplains adjacent to the Mississippi River with concentrations of box elder (*Acer negundo* L.) (Aceraceae), sycamore (*Platanus occidentalis* L.) (Platanaceae), sassafras (*Sassafras albidum* (Nutt.) Nees) (Lauraceae), nutmeg hickory (*Carya* Section *Apo-carya myristicaeformis* (Michx. f. Nutt.) (Juglandaceae), water locust (*Gleditsia aquatica* Marsh.) (Fabaceae), and various oaks (*Quercus* sp.) (Fagaceae). All our adult *C. atocala* were taken by flushing them from resting sites on tree trunks during day-

light hours—none were attracted to our bait traps at night (deployed only one night), and we did not employ MV or UV light traps. Adult *C. atocala* were common at the West Feliciana Parish, Adams County, and Issaquena County sites, with up to 10–20 moths per hour observed at each. Adults were seen resting head down from 0.5 to 2.0 m above the ground on the trunks of various trees, most often box elder and nutmeg hickory, and usually adjacent to or under vines ca. 1–4 cm in diameter. When startled, adult *C. atocala* proved to be among the wariest of any *Catocala* species we have encountered, and displayed a penchant for alighting repeatedly on the often inaccessible vines; pursuits of 10–20 minutes per moth were not uncommon. Adult *C. atocala* were flushed from trees as early as 0715 h at the Saint Francisville locality. Daytime high temperatures throughout the period 28 June to 2 July 1999 ranged from 31–35°C.

The only other *Catocala* species occurring in significant numbers with *C. atocala* in these wooded floodplains was *C. agrippina*. In the Adams County and (especially) Issaquena County localities, adult *C. atocala* outnumbered adult *C. agrippina*. The *Catocala* species encountered at each locality were as follows: Louisiana, West Feliciana Parish: *C. amatrix* Hübner, *C. agrippina*, *C. amica* Hübner, *C. atocala*, *C. carissima* Hulst, *C. ilia* Cramer, *C. insolabilis* Guenée, *C. maestosa* Hulst, *C. piatrix* Grote, *C. vidua* J. E. Smith; Mississippi, Adams County: *C. agrippina*, *C. atocala*, *C. amatrix*, *C. carissima*, *C. innubens* Guenée; Mississippi, Bolivar County: *C. atocala*, *C. agrippina*, *C. innubens*; Mississippi, Coahoma County: *C. agrippina*, *C. atocala*, *C. carissima*, *C. innubens*; Mississippi, Tunica County: *C. agrippina*, *C. atocala*, *C. innubens*; Mississippi, DeSoto County: *C. maestosa*.

#### REARING OBSERVATIONS

Ova were secured from two of six moderately worn female *C. atocala* collected during the day from Saint Francisville, Louisiana, between 30 June and 4 July 1999. The females were confined in paper grocery bags (8 × 13.5 × 27 cm) at near ambient temperature (15–30°C), and were offered a weak sucrose solution daily on small pieces of sponge; a new sponge piece with solution was provided approximately every other day. Although females lived from three to eight days, only two oviposited, and each of these deposited only three ova. One set of ova was overwintered at ambient outside temperatures in Gainesville, Alachua County, Florida by JRS (coldest periods of circa 5 to 10°C), and another in a protected garage in Westport, Fairfield County, Connecticut by LFG (coldest periods of circa –2 to 5°C). Overwintering ova were kept in empty



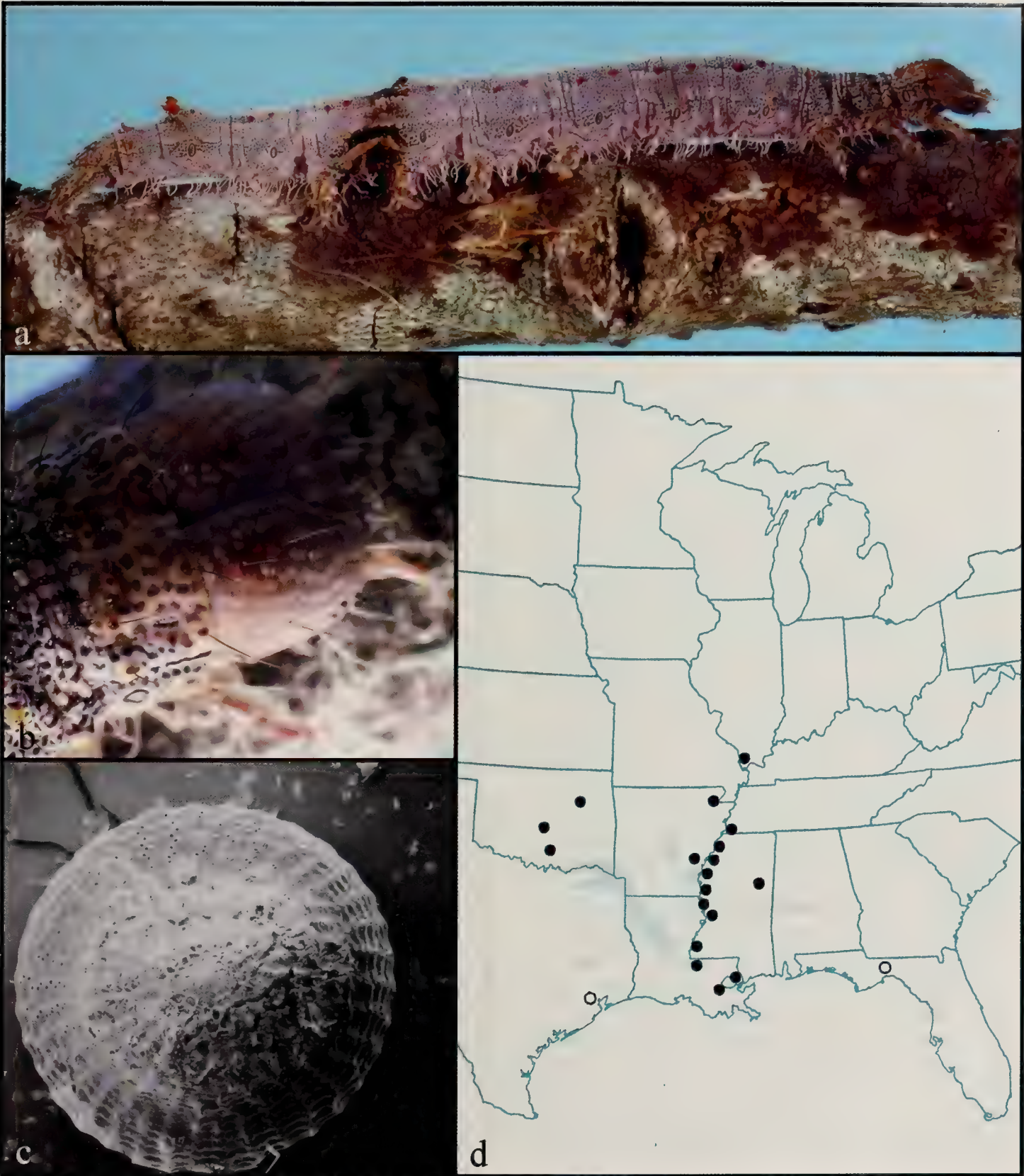


FIG. 1. Immature stages and distribution of *Catocala atocala*. **a**, lateral view of 6th (last) instar larva. **b**, closeup of head capsule of 6th instar larva. **c**, dorsal view of egg as revealed by scanning electron microscopy (60×). **d**, distribution of *Catocala atocala* in North America; open circles, pre-1950 records; filled circles, post-1950 records; each circle represents a county in which the species has been recorded; shading represents distribution of *Carya* (Section *Apocarya*) *myristicaeformis* (after Little 1977, 1980).

plastic film containers and misted lightly once every few weeks.

Only one first instar larva emerged on 14 April 2000 from the three ova overwintered in Florida, and only

one emerged on 12 May 2000 from the three ova overwintered in Connecticut. The Florida larva was offered only water hickory (*Carya* Section *Apocarya* *aquatica* (Michx. f.) Nutt.), which it accepted. The



Connecticut larva was offered an array of potential juglandaceous foodplants in an arena food choice test (see Gall 1991); it accepted black walnut (*Juglans nigra* L.) and butternut (*J. cinerea* L.), but refused to feed on shagbark hickory (*C. Section Eucarya ovata* (Mill.) K. Koch), pignut hickory (*C. Section Eucarya glabra* (Mill.) Sweet), and bitternut hickory (*C. Section Apocarya cordiformis* (Wang.) K. Koch). This larva subsequently was reared on *J. nigra*. Both larvae were reared indoors at 20–24°C, and each appeared to eat their respective foods equally well, as development times per larval instar differed by one day or less. Both larvae were preserved in alcohol as fully grown last instars. The average duration for each stage was as follows (based on  $n = 2$  larvae): 1st instar, 4 days; 2nd instar, 4 days; 3rd instar, 3.5 days; 4th instar, 4.5 days; 5th instar, 5.5 days; 6th instar >5 days (larvae were preserved before entering pre-pupal stage). A description of the mature larva is as follows:

**6th (final) instar larva** (Figs. 1a, b). Length 6 cm; head capsule width 3–4 mm; body color light mousy grey tinged with pink; dorsal tubercles reddish orange; spiracles black; finely dispersed black to brown specks forming interrupted but nearly complete dorsal and lateral lines along length of body, most apparent in the vicinity of the dorsal tubercles; 5th abdominal segment with slightly elevated, 2 mm wide transverse protuberance, slightly lighter than body color, with a large dark brown lateral “saddle patch” contrasting strongly with the body color, all lines formed by specks being darker and more prominent on this segment; 8th abdominal segment with a pair of ventrally projecting, 1 mm long tubercles; lateral filaments present along entire length of body, whitish pink, dense, 1–2 mm in length, simple (not bifurcate or multifurcate); ventral surface of body segments dirty whitish pink, with black spots on each abdominal segment, edged and overlaid with orange on 4th through 7th abdominal segments; capitad surface of head capsule flattened but not strongly produced addorsally, lacking lateral stripes from antennae to dorsal margins; antennae and true legs pinkish; setae on head capsule and body pinkish, sparse; head capsule color same as body color, but with slightly darker striations; based on limited sample sizes, the larva of *C. atocala* appears to have a more prominent “saddle patch” than the larva of *C. agrippina*, and the first few dorsal tubercles behind the head capsule in *C. agrippina* are usually yellowish, as opposed to reddish orange in *C. atocala*.

It is unlikely that *Carya aquatica* or *Juglans nigra* are the wild larval foodplants of *C. atocala* at the Louisiana or Mississippi localities visited during 1999. No *Carya aquatica* were seen at these localities, and *J. nigra*, *Carya Section Eucarya ovata*, and *Carya Section Apocarya illinoensis* (Wang.) K. Koch (pecan) occurred only sporadically, and then not in close proximity to the adult moths. However, *Carya myristicaeformis*, the only other juglandaceous tree species at any of the *C. atocala*

collecting sites, was present and often common where the moths were found, and was one of the tree species on which the adults frequently rested during the day-time. In addition, the overall geographic range of *Carya myristicaeformis* approximates the known range of *C. atocala* (Fig. 1d). We thus believe *Carya myristicaeformis* is the wild foodplant for *C. atocala* along the Mississippi River in Louisiana and Mississippi. Because another global stronghold for *Carya myristicaeformis* appears to be along the Red River and its tributaries on the border of Oklahoma and Texas, we predict that *C. atocala* occurs there in greater numbers than the few recent Oklahoma captures (Cleveland, Murray and Tulsa Counties; G. Gier & C. Harp, pers. com.) suggest. In addition, disjunct populations of *Carya myristicaeformis* that could harbor *C. atocala* exist in coastal South Carolina. We encourage lepidopterists to look for *C. atocala* and *Carya myristicaeformis* in these other drainage systems, as well as at greater distances from rivers per se, as our sampling efforts during 1999 were at best inconsistent the farther we were from the Mississippi River.

#### ACKNOWLEDGMENTS

We thank Vernon Brou for his hospitality in Louisiana during 1999, and for sharing his catocalating experiences in that state. Wolfram Mey and Wolfgang Speidel provided access to the collections at the Museum für Naturkunde in Berlin to LFG. Wayne Miller and Jim Tuttle helped JRS in the field at the Saint Francisville locality. Jeff Cott took the larval photographs, and John Brown provided helpful comments on the manuscript.

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## DISTRIBUTION AND BIOLOGY OF *ANISOTA MANITOBENSIS* (SATURNIIDAE) IN SOUTHERN MANITOBA

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**ABSTRACT.** The known distribution of the saturniid moth, *Anisota manitobensis* is limited to southern Manitoba and northern Minnesota. To date, nothing has been reported in the literature about adult emergence times and adult mating activity. In this paper, the known distribution of *A. manitobensis* in southern Manitoba is summarized, information on larval collection techniques is provided, and new information on adult emergence times and adult mating activities are given. Adults begin emerging at approximately 0600 h (CDT), with a few delaying emergence until between 2100 and 2200 h (CDT). Adult females of *A. manitobensis* call from 0630 to 0900 h (CDT) and, if not mated, again from 0100 to 0300 h (CDT).

**Additional key words:** *Anisota stigma*, bur oak, calling females, larvae, oakworms.

The saturniid moth *Anisota manitobensis* McDunnough is known from southern Manitoba, northern Minnesota, and may possibly occur in northeastern North Dakota (McGugan 1958, Tuskes et al. 1996). *Anisota manitobensis* was reported from Wisconsin by Riotte and Peigler (1981). However, these records have been disputed by Tuskes et al. (1996). The known distribution of *A. manitobensis* is based largely on very old collection records. There are relatively few collection records for *A. manitobensis*, and almost none from the last 25 years. Nothing was known about adult emergence times, adult female calling times, the length of the mating period, or oviposition behavior of this species.

This paper summarizes most of the available collection records for this moth in southern Manitoba. These locality records were utilized in an attempt to locate this species in the field. In 1996, and again in 1997, *A. manitobensis* was collected at Fullers, Manitoba. Larvae were located on very small bur oak (*Quercus macrocarpa* Michaux) trees, in semi-open areas. New information about adult emergence times and female calling times indicate that adults begin emerging at approximately 0600 h (CDT). A few individuals delayed emergence until between 2100 and 2200 h (CDT). Adult females of *A. manitobensis* call from 0630 to 0900 h (CDT) and again from 0100 to 0300 h (CDT), if not mated during the morning calling period.

### MATERIALS AND METHODS

A search for colonies of *Anisota* spp. in southern Manitoba was conducted annually from 1989 to 1996. Using the available collection records, many of the localities in Manitoba where species of this genus have been collected in the past were extensively searched, often on more than one occasion. With the exception of a single locality record for *A. virginensis* (Drury) at Belair, Manitoba, efforts at locating *Anisota* spp. (e.g., black lighting, searching for larvae) yielded no additional colonies. Virgin females of the closely related *A. stigma* Fabricius (courtesy of Mr. J. P. Tuttle) were also

employed in an effort to locate colonies of *A. manitobensis* in and around Winnipeg.

*Anisota manitobensis* larvae were maintained on foliage of *Q. macrocarpa*. Pupae were placed in moist peat and overwintered at 5°C. Pupae were removed from cold storage in early May and placed in shaded outdoor cages to ensure exposure to ambient temperatures and photoperiod. Voucher specimens have been retained in the personal collection of the author.

### RESULTS

**Historical distribution** (Fig. 1). According to the relevant literature (McDunnough 1921, Brodie 1929, McGugan 1958, Ferguson 1972, Riotte & Peigler 1981, Tuskes et al. 1996), and museum records (J. B. Wallis Museum of Entomology [JBWM], Manitoba Museum of Man and Nature [MMM], and the Transcona Historical Museum [THM]), *A. manitobensis* has been collected at the following southern Manitoba localities:

**Anola:** 26 June 1976 (Tuskes et al. 1996), **Aweme** (8 km north of Treesbank): 23 June 1904 (McDunnough 1921), 29 June 1907 and 4 July 1907 (McDunnough 1921), ([larva] August 1912 [JBWM]), **Birds Hill:** 20 July 1963 (THM), **Brandon:** 15 July 1950 (JBWM), **Darlingford:** (Riotte & Peigler 1981), **Kelwood:** (Riotte & Peigler 1981), **Killarney:** 10 July 1947 (JBWM), **McCreary:** (Riotte & Peigler 1981), **Middlechurch:** July 1954 (JBWM), **Pine Ridge:** (Riotte & Peigler 1981), **Riding Mountain National Park:** 19 June 1936 (Ferguson 1971), **Sandilands Provincial Forest:** 25 June 1971 (C. S. Quelch field notes—THM), **Souris:** June 1954 (JBWM), **1 mi. W. Vivian:** 30 June 1967 (C. S. Quelch field notes—THM), **Winnipeg:** July 1920 (JBWM), 10 June 1921 and 16 June 1921 (JBWM), 8 June 1928 (JBWM), 29 June 1928 (Brodie 1929), 3 July 1930 (JBWM), 22 June 1948 (JBWM), 5 July 1949 (JBWM), 10 July 1950 (THM), 26 June 1954 and 2 July 1954 (THM), 14 July 1955 (THM). Criddle (1932) reported *A. manitobensis* from the area south of Carman, where three acres of bur



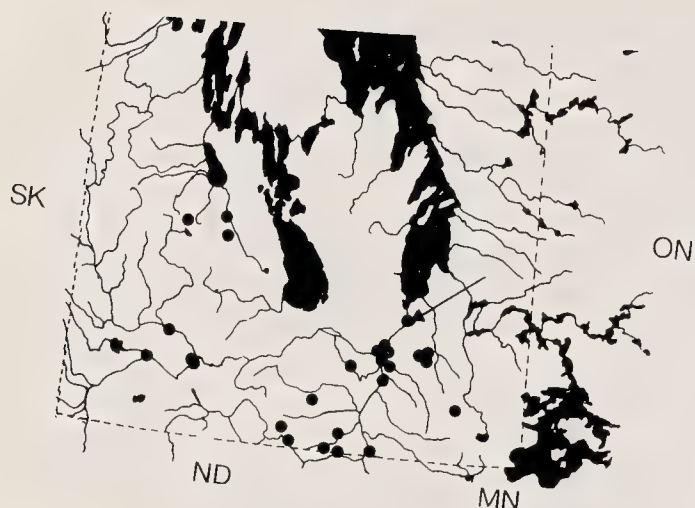


FIG. 1. Distribution of *Anisota manitobensis* in southern Manitoba. Locality of most recent collection at Fullers indicated by arrow.

oak were severely defoliated in 1931. Criddle also mentioned Onah and Treesbank as other localities where *A. manitobensis* larvae were collected that same year.

**New collection locales.** On 20 August 1996, two late fifth-instar *A. manitobensis* larvae of opposite sex were collected east of Fullers, Manitoba. This locality is approximately 5 km north of East Selkirk, along highway #508. As with other saturniid larvae, larvae of *Anisota* can be sexed according to the presence or absence of a small dark spot on the venter of the ninth abdominal segment. This spot is associated with the male genital histoblast (Miller 1977). Larvae having this spot are males and those lacking this spot are females. These larvae were found feeding on the foliage of a small bur oak that was approximately 150–180 cm in height. An egg cluster containing 16 eggs was located on the tip of an oak leaf at the end of a branch, approximately 45 cm above ground level and facing south. Of these 16 eggs, 12 had eclosed and the other four contained dead embryos. On 22 August 1996 a second collection consisting of a single late fifth-instar female larva was also made, approximately 1 km west of the first collection. This larva was also collected from a small bur oak tree that was only 75 cm in height and >90% defoliated; no egg cluster was located. It was evident that several other larvae were also present on this tree but had probably wandered away to pupate. At both collection points, the oak trees on which these larvae were collected were isolated (i.e., >150 cm) from other trees, had low surrounding vegetation, and were receiving full sunlight. In the laboratory, all three larvae wandered for approximately two days after feeding was completed, and pupated approximately three days after wandering ceased. All larvae turned a mottled green color several days prior to pu-

pation. The same locality was revisited in June 1997. A cluster of 75 second-instar larvae was found on a terminal oak leaf, only 30 cm above the ground and facing west, in full sunlight, and along the forest-field interface. Sixty-five pupae were obtained from this collection (32 males, 33 females).

**Morphological comparisons** (Fig. 2). According to Brodie (1929) mature *A. manitobensis* larvae possess pale tan head capsules. Examination of the larvae collected near Fullers revealed that the head capsule is clearly orange, as in mature larvae of the closely related *A. stigma* (Riotte & Peigler 1981). In addition, the single larva collected on 22 August 1996 differed from the other two in that the dorsal stripe and shading described by Brodie were very faint and barely visible. Color photos of these larvae can be viewed at <http://www.lsu.edu/faculty/dhenne1/>. Brodie (1929) also described the pupa of *A. manitobensis* as reddish-brown in color. Although this color was observed for the first few days following pupation, the pupae eventually darkened to a brownish-black color. Confirmation of the larval collections as being *A. manitobensis* was obtained the following June when adults emerged from overwintered pupae. Adults closely resembled museum specimens of *A. manitobensis*. The specimens obtained lacked any heavy spotting of the wings, a trait characteristic of *A. stigma*. Examination of male genitalia of specimens of *A. stigma* from Anne Arundle Co., Maryland, compared with those of the specimens collected at Fullers also confirmed the identity of *A. manitobensis*.

**Mating activity.** Adult emergence times, female calling times, length of pairing, and oviposition habits for *A. manitobensis* were unknown until this time. Adults obtained from these collections emerged in the morning, around 0600 h (CDT). Females began calling as soon as their wings were fully expanded, often within 30 minutes of eclosion. Most females had their ovipositors everted from approximately 0630 to 0900 h (CDT). If unmated during this time these females would exhibit a second calling time, from approximately 0100 to 0300 h (CDT). These calling times are similar to those reported for *A. stigma* (Tuskes et al. 1996). Some adults delayed emergence until between 2100 and 2200 h (CDT), which is shortly after sunset in southern Manitoba during early June. Length of pairing at night was variable, ranging from one to several hours. Adults mated during the morning hours remained in copula until dusk, at which time females would begin ovipositing. This behavior is very similar to that reported for *A. stigma* in Tuskes et al. (1996). Oviposition behavior after separation of adults was difficult to observe. Most females placed in paper sacks



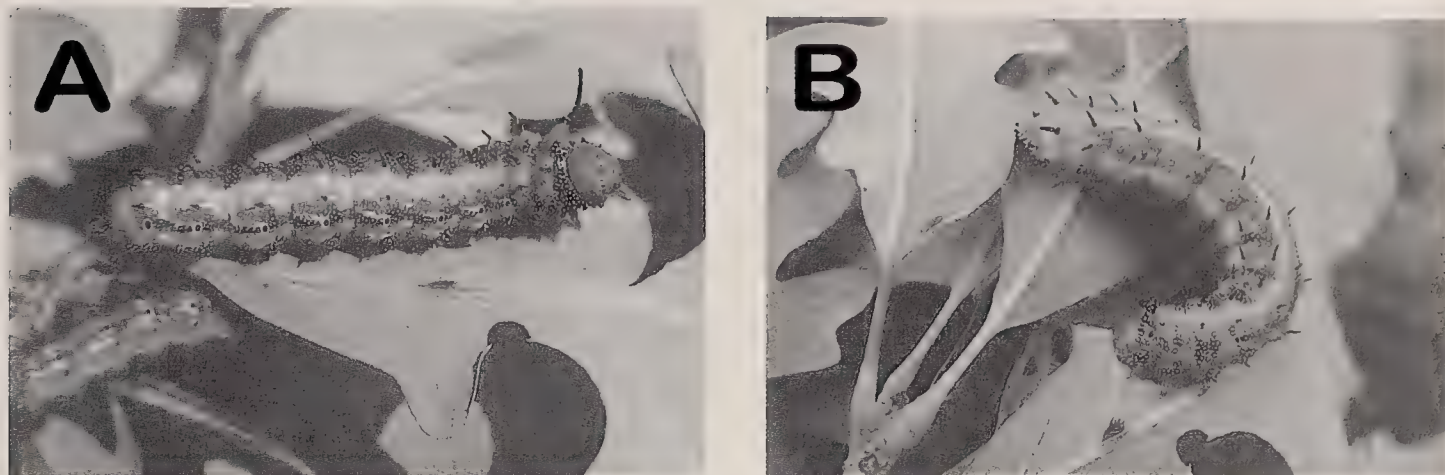


FIG. 2. Fifth-instar larvae of *Anisota Manitobensis*. (A) lateral view, (B) dorsal view

after pairing ceased refused to lay eggs. A single female, however, deposited 185 eggs inside a paper sack, over a three-day period. Egg laying activity was not observed.

#### DISCUSSION

*Anisota Manitobensis* was a very difficult species to locate in the field. McGugan (1958) reported *A. Manitobensis* larvae as locally abundant in some areas of the Red River Valley of southern Manitoba but also stated that it is generally found in small numbers. This would appear to be the case with the population at Fullers, Manitoba. Evidence of bur oak defoliation typical of feeding by larval *Anisota* was also noted near East Selkirk, and in an area east of Winnipeg, just south of Pine Ridge. No larvae or egg clusters were found at these localities. Gregarious larvae of *Datana ministra* (Drury) were common in these areas and were noted for the similar method by which they defoliated bur oak. Larvae of *Anisota* and *Datana* consume all of the oak leaf, with the exception of the mid vein. Riotte and Peigler (1981:113) also found *Datana* to be common and similarly interfered/confused their searching for *Anisota*. It was also noted that agricultural areas now isolate many of the localities where *A. Manitobensis* was collected in the past. Local extirpations of this insect have likely occurred on a large scale, but it is beyond the scope of this paper to speculate on the population status of this insect. If it is indeed rare, then it needs to be protected. We still know very little, however, about population dynamics of most *Anisota* spp. The low populations may only be a cyclic phenomenon. Alternatively, it may be possible that this species prefers oak stands of a limited age, i.e., older stands of oak may not be suitable habitat for *A. Manitobensis*.

The similarity of calling times of *A. Manitobensis* and *A. stigma* females may support the notion of Tuskes et al. (1996) that *A. Manitobensis* is only a clinal

variant of *A. stigma*. Unfortunately, there is a huge gap in collection records between *A. Manitobensis* in Manitoba and the nearest records for *A. stigma* in Minnesota and Wisconsin. Material from this region could be useful in solving the question as to whether *A. Manitobensis* should be recognized as a full species or not. The failure of *A. stigma* females to attract *A. Manitobensis* males does not necessarily indicate that some form of prezygotic isolating mechanism isolates the two species. Instead, it may mean that *A. Manitobensis* was simply not present in the localities where *A. stigma* females were deployed. Unfortunately, live-stock of *A. stigma* was not available to be tested on a known population of *A. Manitobensis*.

#### ACKNOWLEDGMENTS

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# THE LARGE MOTHS OF GUANA ISLAND, BRITISH VIRGIN ISLANDS: A SURVEY OF EFFICIENT COLONIZERS (SPHINGIDAE, NOTODONTIDAE, NOCTUIDAE, ARCTIIDAE, GEOMETRIDAE, HYBLAEIDAE, COSSIDAE)

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*"Good boys go to heaven, but the bad boys go everywhere"\**

Meatloaf 1993

**ABSTRACT.** An illustrated and annotated list of large moths of Guana, a 297 ha island located on the north side of the Caribbean island of Tortola, British Virgin Islands, is presented. Of the 148 species listed, 98 are distributed throughout the neotropics, 41 throughout the Antilles, with some ranging into Florida, and 9 endemic to the Puerto Rican Bank, two of them described here: *Catabenoides lazelli*, **new species**, and *Perigea gloria*, **new species**. The following new synonyms and new combinations are recognized: *Leucania solita* Walker, **new synonym** [= *L. humidicola* Guenée], *Kakopoda cincta* Smith, **new synonym** [= *K. progenies* (Guenée)], *Drepanopalpia polycyma* Hampson, **new synonym** [= *D. lunifera* (Butler)], **new combination**, *Sphacelodes fusilineatus* Walker, **revised status**, *Idaea fernaria* (Schaus), **new combination**, *Ptychopoda curtaria* Warren, **new synonym** [= *Idaea minuta* (Schaus)], *Pterocypha defensata* Walker, **revised status**, is recognized as the senior synonym of *P. floridata* (Walker), **new synonym**, reversing a recently published synonymy. A new genus, *Catabenoides* Poole, **new genus**, type-species: *Laphygma vitrina* Walker, is described in an appendix, including *C. divisa* (Herrich-Schäffer), **new combination**, *C. seorsa* (Todd), **new combination**, and *C. terens* (Walker), **new combination**, all by Robert W. Poole. The palatability to birds of two species, *Diphthera festiva* and *Calidota strigosa*, was observed and the species were shown to be distasteful.

**Additional key words:** Caribbean, West Indies, biogeography, taxonomy, palatability.

Guana is a small island on the north side of Tortola in the British Virgin Islands (18°28'N, 64°35'W) (Fig. 1). While it is small, only 297 ha, and the maximum elevation is 266 m, it supports a relatively rich vegetation and has sustained less damage by feral animals and humans than have many adjacent islands (Lazell 1996). It has most of the floristic associations of the larger Virgin Islands, with the notable exception of the "aridulate rain forest" of Tortola (D'Arcy 1967). Despite its small size, Guana has a diverse insect fauna (Davies & Smith 1997). For example, Guana has 31 species of butterflies (Becker & Miller 1992), compared to the larger islands of Anegada (3872 ha) (Smith et al. 1991) with 24 species and Tortola (5444 ha) with 31 species, and St. Thomas (7660 ha) with 32 species (Miller 1994). Alminas et al. (1994) review the geographical setting of the Virgin Islands.

This is the first survey of the moth fauna of this island. John F. G. Clarke was on Guana briefly in 1956 and 1958 (see Schmitt 1959), but was unable to collect at lights there. Most of the species reported herein are known from Puerto Rico (e.g., Forbes 1930, 1931,

Schaus 1940, Wolcott 1951), but most have not been recorded from the British Virgin Islands due to lack of previous sampling. The faunal similarity to Puerto Rico is expected, given that the principal islands of the Virgin Islands (except Saint Croix) lost their connection with each other and with Puerto Rico only about 8000 to 10,000 years ago, due to eustatic rise in sea level (Heatwole et al. 1981). Only scattered records exist in the literature for moths of the Virgin Islands, with two of the longest lists being Beatty (1948) for St. Croix and Greenwood and Greenwood (1971) for Peter Island.

We are treating the Lepidoptera of Guana Island in parts. Becker and Miller (1992) reported 31 species of butterflies. The present paper reports 148 species of large moths (Macrolepidoptera, including the unrelated Cossidae and Hyblaeidae for convenience), represented by 1390 specimens. The manuscript was prepared using the classification of Noctuidae by Poole (1989), before extensive recent changes in higher classification of Lepidoptera (Kristensen 1998, Holloway et al. 2001). Future papers will treat Pyraloidea and Microlepidoptera.

The moth fauna of Guana is composed primarily of species with wide distributions in the New World tropics (Table 1). Of the 148 species listed, 50 are endemic to the Caribbean Islands, many of them reaching the

\*We often pejoratively regard widespread species as "weed species" or "pests". Parodying the citation above: "Bad" species go everywhere, "good" species [may] go to Heaven [extinct]. But is it fair to consider them bad simply because they are able to get everywhere? Perhaps "efficient colonizers" is a better term?



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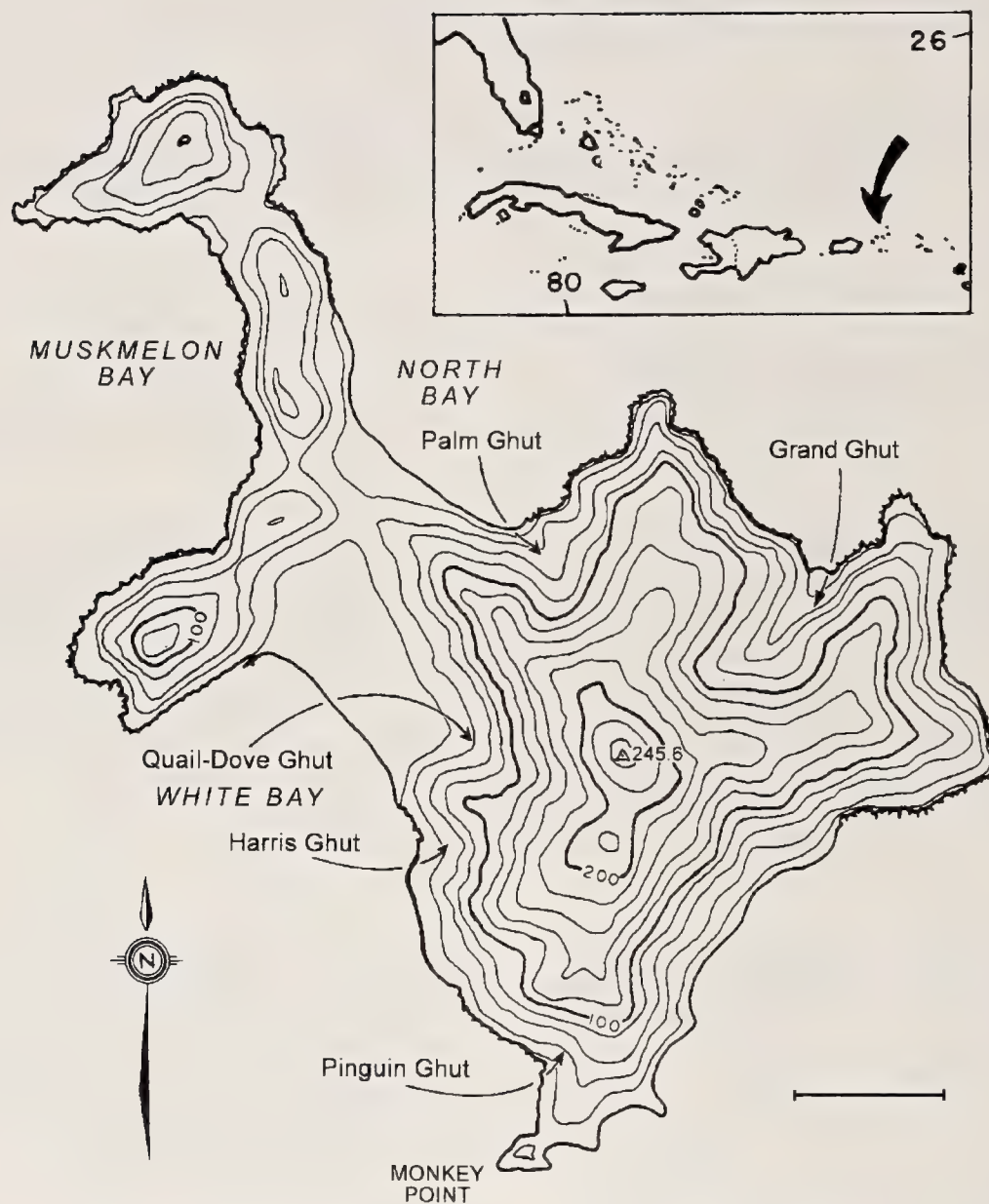


FIG. 1. Map of Guana Island. Contours are 20 m. Bar, bottom right, is 400 m. Inset shows the position of the Virgin Islands in the Antilles.

Florida Peninsula, and only nine apparently are restricted to the Puerto Rican Bank. These proportions, however, are not the same for the different families. The highest degree of endemism occurs in the Geometridae and Arctiidae, whereas the lowest occurs in the Sphingidae. This is presumably because of the powerful flying capacity of sphingids, while geometrids and arctiids are clumsy flyers.

Holloway and Nielsen (1998, following Ferguson et al. 1991) presented a chart of 12 moth genera that are widely recorded from remote islands worldwide. Of these, nine genera (including 20 species) are present on Guana (counting *Leucania* as *Mythimna*). It is likely that the remaining three genera, especially *Agrotis*, may be found on Guana in the future. Many of the species whose ranges include the southern United

States (especially Sphingidae) also occur as vagrants in the Northeast United States and into Canada (e.g., Forbes 1954, 1960). Species recorded from the Galapagos Islands by Hayes (1975) are noted as indication of their dispersal ability (note that none of the Geometridae recorded from Galapagos are also known from Guana).

#### MATERIALS AND METHODS

The material upon which this list is based was collected in July 1984 and 1985 (by S. E. Miller & P. M. Miller), July 1986 (S. E. Miller & M. G. Pogue), July 1987 (S. E. Miller & V. O. Becker), July 1988 (S. E. Miller & C. O'Connell), October 1989 (V. O. Becker), and October–November 1990 (S. E. Miller & T. M. Kuklenski). Collections from 1984–1986 are deposited



TABLE 1. Geographic range of the species of moths collected at Guana Island.

Family	Number of species			Total
	Neotropical*	Antilles	Puerto Rican Bank	
Sphingidae	20	2	0	22
Notodontidae	1	0	0	1
Noctuidae	63	16	3	82
Arctiidae	6	5	4	15
Geometridae	6	18	2	26
Hyblaeidae	1	0	0	1
Cossidae	1	0	0	1
Total	98	41	9	148

\* Includes Cosmopolitan and Pantropical species.

at the National Museum of Natural History (USNM), Washington, those of 1987–1990 are split between first author (VOB), Bishop Museum, Hawaii (BPBM), and USNM. The largest collections were made by both authors 9–23 July 1987, with over 2200 specimens representing about 300 morphospecies, and by the first author in October 1989, with over 2000 specimens representing over 350 morphospecies.

The list of species by family collected during the 1989 trip (Table 2) gives an impression of the overall fauna, especially the diversity of Microlepidoptera, still under study. Of the 359 species recorded, 243 species (two thirds) are Microlepidoptera and pyraloids, and 163 (nearly one half) are pyraloids and gelechioids.

The number of specimens listed in this work under each species does not reflect relative abundance, as our objective was only to list the species occurring on the island. Therefore, in the case of species that are common in other parts of the neotropics only one or a few specimens were collected to voucher the record, independent of their abundance. In contrast, in the case of endemic or rare species, usually all specimens were caught.

The results obtained by the first author during the 1989 trip were a surprise, as it was made 20–40 days after Hurricane Hugo had devastated the island on 18 September. The damage was still evident: all buildings without roofs and without most of their doors and windows, and fallen trees and torn branches scattered all over the island. According to people who were on the island the day Hugo hit, not a single leaf remained on the trees. At the time of arrival (9 October) the island was completely green again. That same night the collecting was fantastic, as were most nights during the next 20 days. Not only the quantity, but also the quality of the material was impressive. It seemed that all specimens had emerged that day. Certainly all caterpillars that had reached development had to pupate

TABLE 2. Moth species collected on Guana Island between 10 and 20 October 1989.

Family	Number of species
Sphingidae	10
Notodontidae	1
Noctuidae	69
Arctiidae	12
Geometridae	24
Hyblaeidae	1
Crambidae	51
Pyralidae	36
Pterophoridae	4
Oecophoridae	2
Blastobasidae	13
Gelechiidae	45
Scythrididae	1
Cosmopterigidae	15
Psychidae	1
Tineidae	35
Gracillariidae	13
Yponomeutidae	1
Argyresthiidae	1
Heliodinidae	2
Choreutidae	1
Cossidae	1
Tortricidae	19
Opostegidae	1
Total	359

immediately after the hurricane, and they were all emerging together. Leaf mines were also abundant. As these tiny species usually have shorter life cycles, they had time to emerge and lay eggs in the 20 days that preceded the field work. Torres (1992) documented the impact of Hurricane Hugo on Lepidoptera populations on Puerto Rico.

A synoptic collection, containing at least one specimen representing each form, was taken to the Smithsonian Institution (USNM), Cornell University (CU), and most importantly, to the Natural History Museum (BMNH), London, by the first author. The list below is a result of the identifications made by comparing this synoptic collection with identified material, especially type specimens (including important voucher specimens and types from Forbes 1930, 1931, Schaus 1940). The first author has compiled a synonymic list of Antillean Lepidoptera (Becker in prep.), which has provided further taxonomic background.

This report is aimed not only at lepidopterists, but also at biologists and students interested in the fauna of the Virgin Islands. For this reason we give a brief synopsis of each species to provide a context and to suggest what kind of observations should be undertaken. Information on each species is provided under the following headings: ID: Diagnostic characters allowing identification of the species in the context of



the other species know from Guana Island; DIST: General distribution of the species, as represented in the literature and VOB and USNM collections; GUANA: The Guana Island specimens seen by us in preparing the manuscript (see the introduction for the dates sampled each year); BIO: Known host records, sometimes including notes on immature stages; COM: Any other comments.

## SPECIES ACCOUNTS

### SPHINGIDAE

Eighty five species of sphingids have been recorded from the Antilles (Becker in prep.), 22 (25%) of them were collected by us in Guana. Color illustrations of adults can be found in Hodges (1971) and D'Abrera (1986); color illustrations of larvae can be found in Moss (1912, 1920).

#### Sphinginae

##### *Agrius cingulatus* (Fabricius, 1775)

(Sweetpotato hornworm, Pink spotted hawk moth)

ID: Separated from other hawk moths by the pink dots on the abdomen.

DIST: United States south to Argentina, including Galapagos.

GUANA: 1 specimen, 1989.

BIO: The variable larvae (green to dark brown) feed on various plants belonging to Convolvulaceae, including sweet potato.

##### *Coccytius antaeus* (Drury, 1773)

(Giant sphinx)

ID: Distinguished from other sphingids on the island by the dark green wings and three pairs of yellow dots on the abdomen.

DIST: Southern United States to Argentina; not in Galapagos.

GUANA: 1 specimen, 1989.

BIO: Green larvae feed on various *Annona* species (Annonaceae) such as custard apple.

##### *Manduca sexta* (Linnaeus, 1763)

(Tobacco hornworm, Carolina sphinx)

ID: Distinguished from other sphingids on the island by the gray wings and six pairs of yellow dots on the abdomen.

DIST: Widespread in the New World, including Galapagos.

GUANA: 5 specimens, 1984, 1988, 1989.

BIO: Pest of cultivated solanaceous plants, such as tobacco, tomato, potato, etc. Mature larvae are green-

yellow with seven pairs of white lateral bands, and red anal horn.

##### *Manduca rustica* (Fabricius, 1775)

(Rustic sphinx)

ID: Distinguished from other sphinx moths on the island by the dark grayish-brown forewing with transverse grayish-white waving bands, and three pairs of yellow dots on the abdomen.

DIST: Widespread New World species, present in Galapagos.

GUANA: 2 specimens, 1984, 1989.

BIO: Larva is greenish-gray, distinguished by its small white nodules on the thoracic segments, mainly on dorsum. They feed on various species of Bignoniaceae, Verbenaceae and Boraginaceae (Hodges 1971).

##### *Manduca brontes* (Drury, 1773)

ID: Distinguished from other species in the genus occurring on the island by the absence of yellow dots on the abdomen.

DIST: Antillean species occurring northward to Central Florida.

GUANA: 1 specimen, 1989.

BIO: The larva is similar to that of the tobacco hornworm but feeds on *Tecoma* (Bignoniaceae) (Hodges 1971).

#### Macroglossinae

##### *Pseudosphinx tetrio* (Linnaeus, 1771)

(Frangipani hornworm)

ID: The largest sphinx on the island; pale gray with irregular darker markings.

DIST: United States throughout the Antilles to Argentina.

GUANA: 7 specimens, 1988, 1990.

BIO: The conspicuous bright caterpillars—banded black and yellow with reddish brown head and orange legs—are frequently seen defoliating frangipani (*Plumeria* spp., Apocynaceae) on the island.

##### *Erinnyis alope* (Drury, 1773)

(Papaya hornworm)

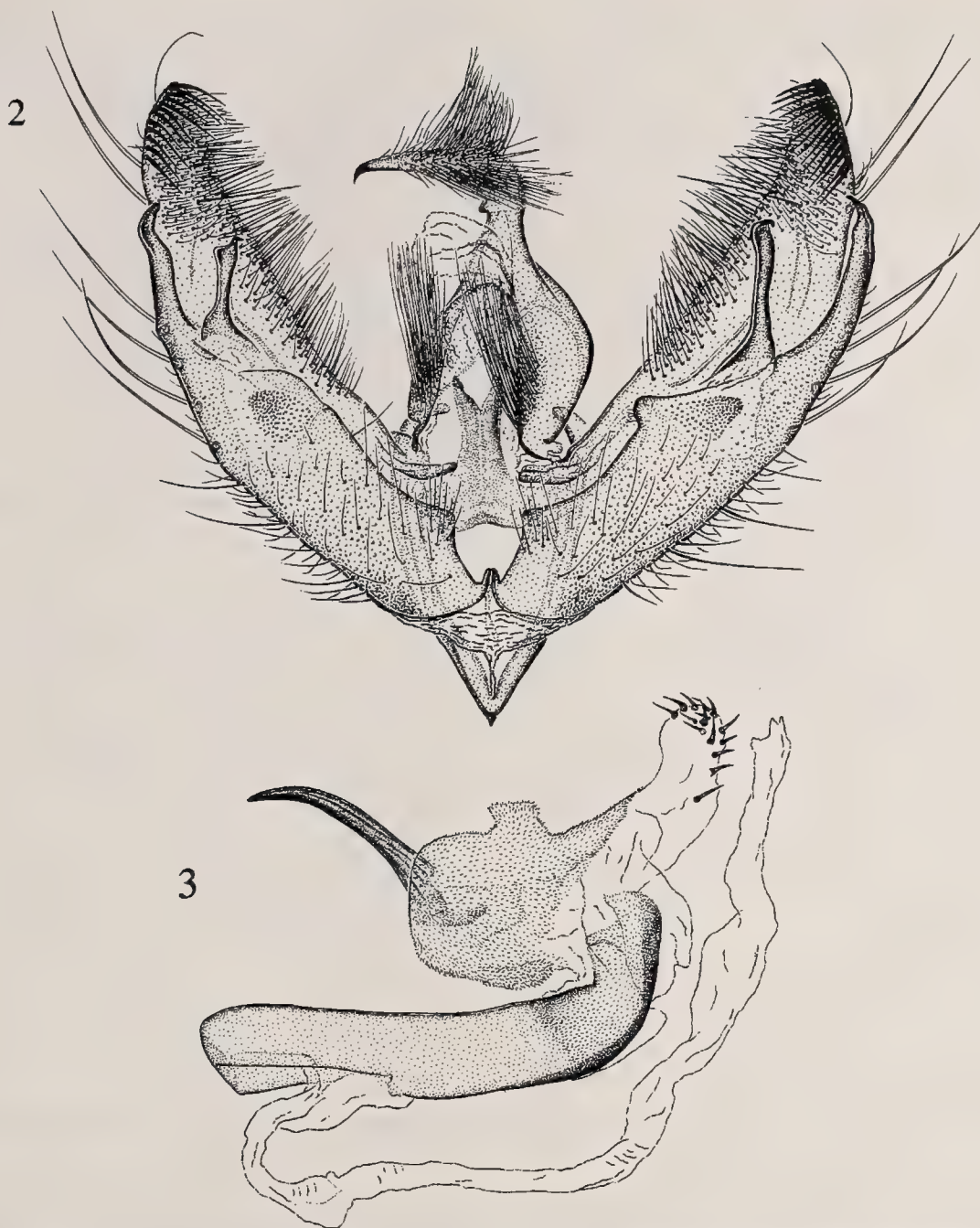
ID: Distinguished from other sphingids on the island by the combination of yellow basal half of hindwing and alternate pairs of light gray and black dots on the abdomen.

DIST: Widespread in the New World, including the Galapagos.

GUANA: 1 specimen, 1989.

BIO: Larvae on a variety of plants with milky sap, such as papaya (*Carica papaya* L., Caricaceae), *Jatropha* (Euphorbiaceae), and *Alamanda* (Apocynaceae).





FIGS. 2–3. Genitalia of *Catabenoides terminellus*. 2, male, ventral view, aedeagus removed; 3, aedeagus, lateral view.

*Erinnyis ello* (Linnaeus, 1758)  
(Cassava hornworm)

ID: Sexually dimorphic. Male forewing dark gray with a blackish irregular band along the wing from near base to apex. Female forewing light gray with almost no markings. Abdomen with pairs of alternate light gray and black dots dorsally.

DIST: The most common species of the genus in tropical America; also in Galapagos.

GUANA: 5 specimens, 1984, 1990.

BIO: Larvae varying in color from yellowish to green and to brownish have been serious pests of cassava (*Manihot*) in tropical America; feeds on various Euphorbiaceae.

*Erinnyis crameri* (Schaus, 1898)

ID: Forewing more brownish than those of *E. ello*; basal area reddish brown and abdomen with indistinct markings.

DIST: Southern United States, through the Caribbean south to Brazil.

GUANA: 1 specimen, 1989.

BIO: Grayish brown larva, figured by Moss (1920: pl. 7, figs. 3a, b), has been reared on various members of the Apocynaceae (Hodges 1971).

*Erinnyis domingonis* (Butler, 1875)

ID: Same size as *E. obscura* (see below) but forewing mostly dark gray.



DIST: Same as *E. obscura*, except for Galapagos.

GUANA: 2 specimens, 1987.

BIO: Unknown.

COM: It is very likely that *E. obscura* and *E. domingonis* are only forms of the same species (Hodges 1971:102, Kitching and Cadiou 2000: note 162). This could be verified by rearing.

*Erinnyis obscura* (Fabricius, 1775)

ID: Similar to *E. ello*, which is also dimorphic, but easily distinguished by its smaller size and absence of dots on abdomen.

DIST: Southern United States throughout the Caribbean south to Brazil, including Galapagos.

GUANA: 4 specimens, 1984, 1987.

BIO: The pale yellowish or pale green larvae have been reared on various milk plants such as *Philibertia* and *Cynanchum* (Asclepiadaceae).

*Pachylia ficus* (Linnaeus, 1758)  
(Large fig hornworm)

ID: Large, dull brown with stout body, quite distinct from other sphingids on the island. Easily recognized by the pale, inverted trapezoidal mark on costa near apex.

DIST: Widespread throughout the New World, but absent from Galapagos.

GUANA: 1 specimen, 1987.

BIO: Moss (1912) figured in color the several forms of the caterpillars, which feed on various species of *Ficus* (Moraceae). Some are green, banded yellow dorsally, while the others are gray brown ventrally and orange, banded black, dorsally.

*Callionima falcifera* (Gehlen, 1943)

ID: Recognized by the orange brown color and the metallic silvery mark near center of forewing.

DIST: Southern United States to Argentina.

GUANA: 4 specimens, 1987, 1990.

BIO: Unknown. Other species in the genus have been reared on some apocynaceous plants (Hodges 1971).

COM: Similar to, and frequently confused with, *C. parce* (Fabricius) (Kitching and Cadiou 2000: note 91). The specimen illustrated as *C. parce* in Hodges (1971: pl. 10, fig. 8) represents this species.

*Perigonia lusca* (Fabricius, 1777)

ID: Medium size dull brown sphinx, recognized by the bright orange area along the middle of hindwing.

DIST: Southern Florida to Argentina.

GUANA: 27 specimens, 1987, 1988, 1989, 1990.

BIO: Bluish green larva, figured in color by Moss

(1912), was reared by him on coffee (Rubiaceae). Recorded from *Gonzalagunia spicata* (Lam.) Maza and other Rubiaceae in Puerto Rico by Torres (1992). COM: Kitching and Cadiou (2000: note 448) review names associated with *P. lusca*.

*Enyo lugubris* (Linnaeus, 1771)

ID: Medium size, dark brown; distinguished from other hawk moths on the island by the dentate borders of both wings.

DIST: Southern United States, throughout the Antilles, south to Uruguay and Argentina, including Galapagos.

GUANA: 3 specimens, 1987, 1989.

BIO: Larvae on *Ampelopsis* spp., *Cissus* spp., and *Vitis* spp. (Vitaceae) (Hodges 1971).

*Aellopos tantalus* (Linnaeus, 1758)

ID: Small, dark gray, diurnal, sphinx moth distinguished by the conspicuous white bar across base of abdomen.

DIST: New York south to Argentina.

GUANA: One specimen captured in a Malaise trap, 1990.

BIO: Larvae on *Ixora venulosa* Benth. (Rubiaceae) (Biezanko et al. 1949).

*Eumorpha vitis* (Linnaeus, 1758)  
(Vine sphinx)

ID: Forewing dark green crossed with grayish bands and dashes, and hindwing with anal margin pink. A beautiful and showy species.

DIST: United States throughout the Caribbean to Argentina (not in Galapagos).

GUANA: 2 specimens, 1987, 1990.

BIO: The larvae vary in color; some are dark pink, others are pale green or yellow green (Moss 1912). They feed on grape leaves (*Vitis* spp.).

*Cauthetia noctuiformis* (Walker, 1856)

ID: The smallest sphingid in the New World, with a wing span slightly over 3 cm. Gray, with basal half of hindwing orange yellow.

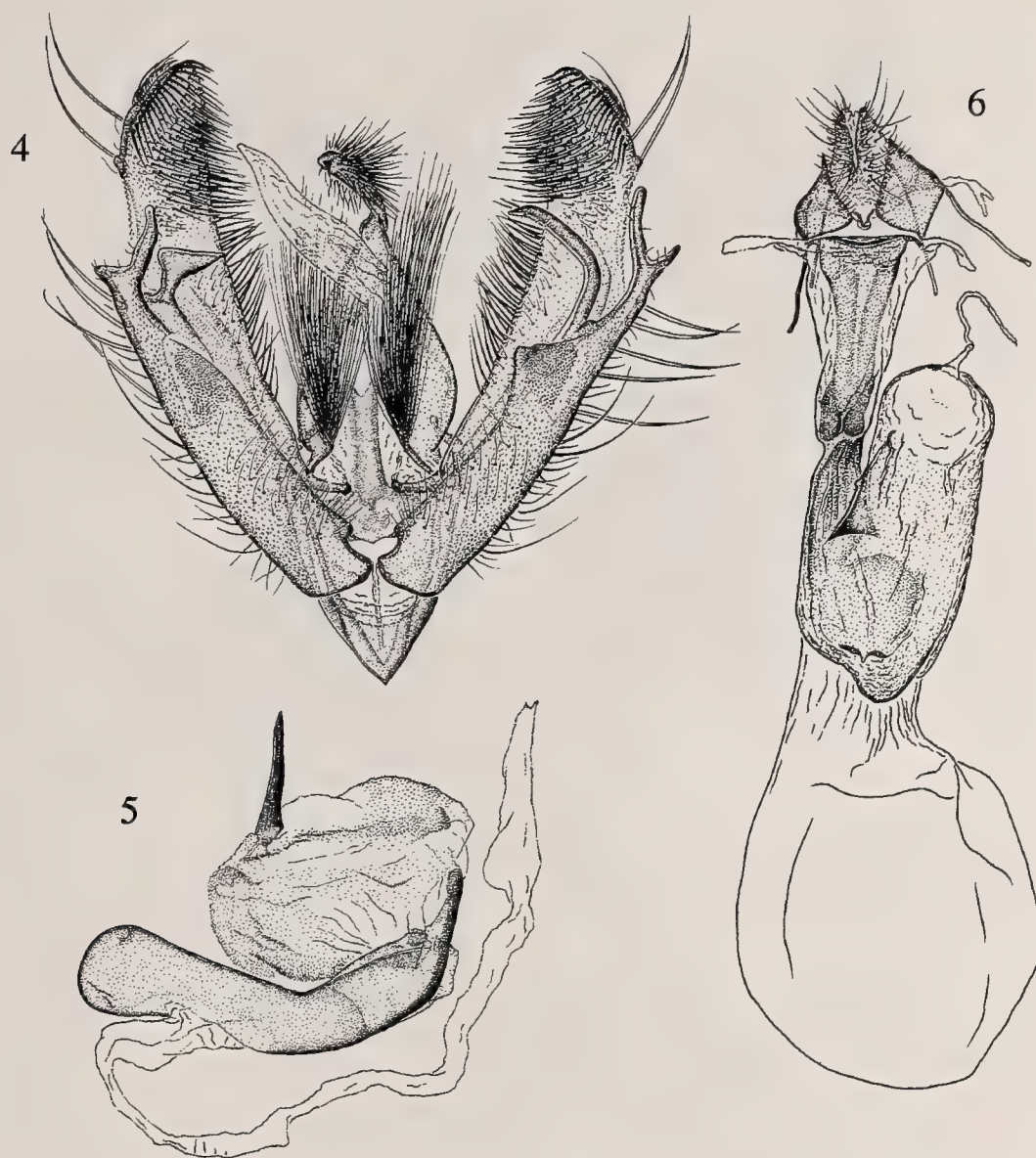
DIST: Caribbean.

GUANA: 166 specimens, 1984, 1986, 1987, 1988, 1989, 1990.

BIO: Unknown, but larvae of *C. grotei* have been reared on *Chiococca alba* (L.) Hitch. (Rubiaceae) (Hodges 1971).

COM: Kitching and Cadiou (2000: note 96) discuss the taxonomy and place the Guana population in the subspecies *C. noctuiformis bredini* Cary, 1970.





FIGS. 4–6. Genitalia of *Catabenoides lazelli*, new species. 4, male, ventral view, aedeagus removed; 5, aedeagus, lateral view; 6, female, ventral view.

*Xylophanes chiron* (Drury, 1770)

ID: Green with an oblique grayish brown irregular band on the forewing looking like a leaf with dead areas.

DIST: Mexico, throughout the Antilles to Argentina.

GUANA: 1 specimen, 1987.

BIO: The showy caterpillar, illustrated in color by Moss (1920: pl. 8, figs. 6a–f), was reared by him on *Palicourea*, *Psychotria*, and *Spermacoce* (Rubiaceae). They are glossy green, bearing pairs of red or white red-ringed eye spots on the first two abdominal segments.

*Xylophanes pluto* (Fabricius, 1777)

ID: Green with irregular transverse light and dark bands. Recognizable by the wide orange band on the hindwing.

DIST: Southern United States to Brazil.

GUANA: 8 specimens, 1987, 1988, 1989, 1990.

BIO: Torres (2000) described larvae from Puerto Rico, reared from *Hamelia patens* Jacq. (Rubiaceae). Gundlach (1881), mentioned by Hodges (1971), also described the larvae, which are of two color forms: one is basically green, the other is black, dark violet and red. Gundlach (1881) recorded the hosts as *Chiococca* (Rubiaceae) and *Erythroxylum* (Erythroxylaceae).

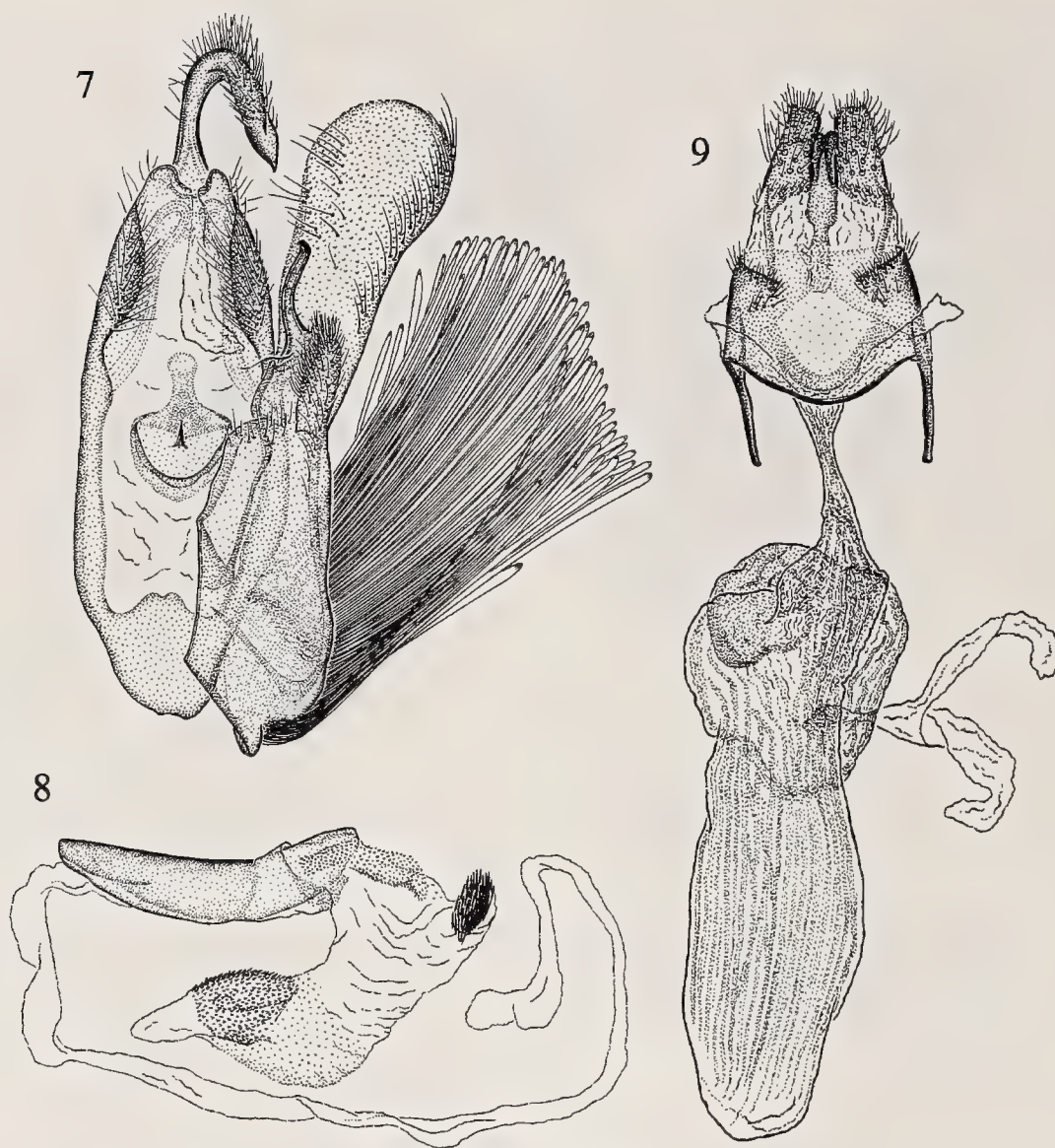
*Xylophanes tersa* (Linnaeus, 1771)

ID: Distinguished from its congeners on the island by the pale greenish gray forewing with several ill-defined, nearly parallel, longitudinal lines, running from base to apex; hindwing black with pale yellow marks in the vein interspaces parallel to the external margin.

DIST: Ontario, across the Antilles down to Argentina, including Galapagos.

GUANA: 4 specimens, 1986, 1987, 1989.





FIGS. 7-9. Genitalia of *Perigea gloria*, new species. 7, male genitalia, ventral view, aedeagus removed; 8, aedeagus, lateral view; 9, female genitalia, ventral view.

BIO: The larvae, beautifully illustrated by Moss (1912: pl. 14, figs. n-q), are yellowish brown with a pair of eye spots laterally on abdominal segments 1-7. The larvae feed on *Psychotria berteriana* DC, *Borreria verticillata* (L.) Meyer and *Diodia sarmentosa* Sw. (Rubiaceae) in Puerto Rico (Torres 1992).

*Hyles lineata* (Fabricius, 1775)  
(White-lined sphinx)

ID: Resembles *E. vitis*, but is distinguished by its smaller size, shorter, clubbed antennae, and single wide fascia running from near base of dorsum to apex of forewing, crossed by whitish lines following the veins.

DIST: This powerful flyer, almost diurnal, has reached all continents, as well as remote islands such as Galapagos and Hawaii.

GUANA: 1 specimen, 1988.

BIO: Polyphagous. Most commonly used plants are

species of *Portulaca* (Portulacaceae), but includes others such as *Fuchsia* (Onagraceae), *Boerhavia* and *Mirabilis* (Nyctaginaceae), *Xanthium* (Asteraceae), and others. Larvae are highly variable in coloration and somewhat in maculation. Some specimens basically are black with a pattern of yellow; others are mainly yellow with some black pattern (Hodges 1971).

#### NOTODONTIDAE

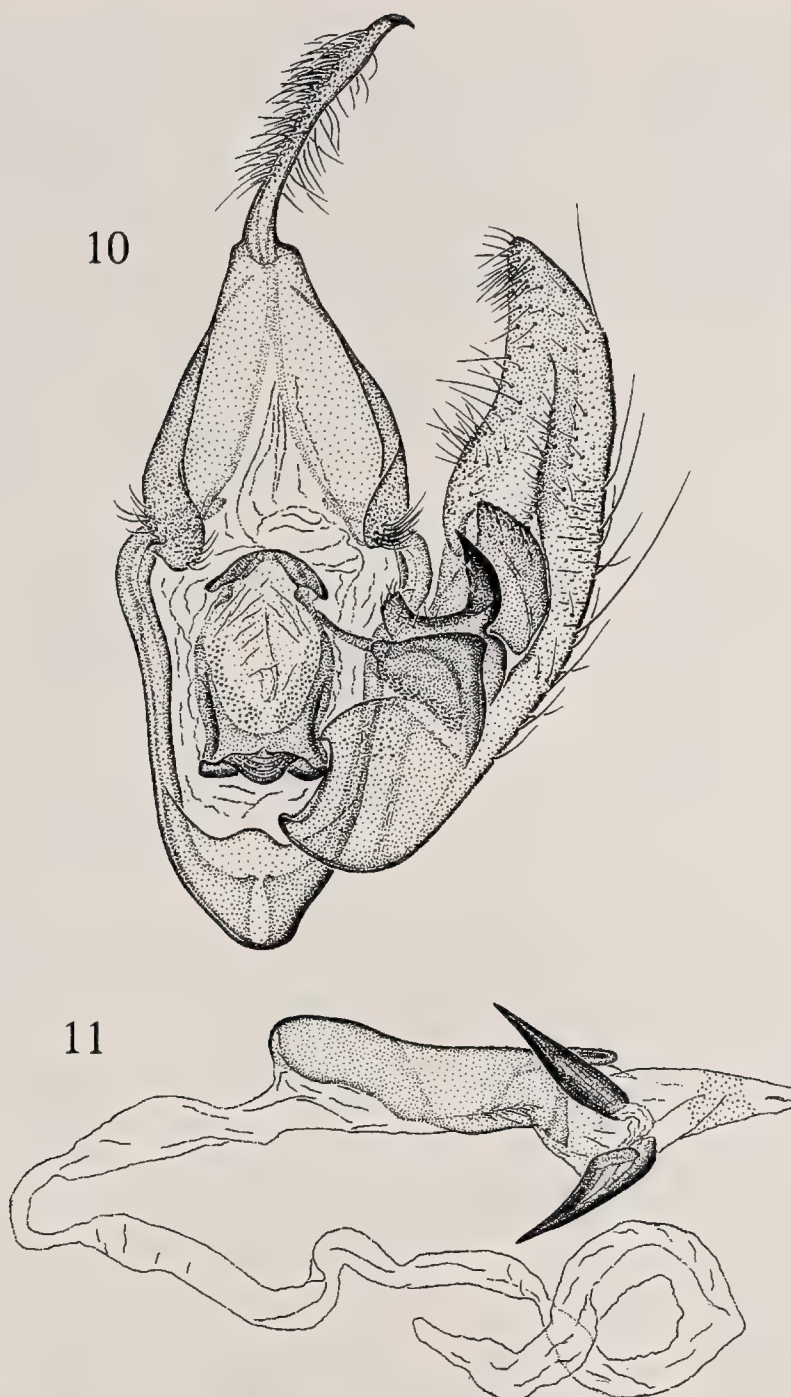
*Nystalea nyseus* (Cramer, 1775)  
(Fig. 15)

ID: Narrow winged, light gray, mottled with dark brown and black scales; recognized by the long scales on the base of antennae that forms a crest on top of the head when resting.

DIST: Mexico, throughout the Caribbean south to Brazil.

GUANA: 3 specimens, 1989.





FIGS. 10, 11. Male genitalia of *Anateinoma affabilis*. 10, ventral view, left valva and aedeagus removed; 11, aedeagus, lateral view.

BIO: Larvae feed on various Myrtaceae especially on species of *Psidium* (Todd 1973:271).

COM: This is the only notodontid present on the island; less than 30 species have been recorded from the Antilles (Becker in prep.). Notodontidae typically occur in moister forests.

NOCTUIDAE

Heliothinae

*Heliothis subflexa* (Guenée, 1852)  
(Fig. 16)

ID: Medium sized, pale olive green; forewing crossed with three olive bands, edged pale basad.

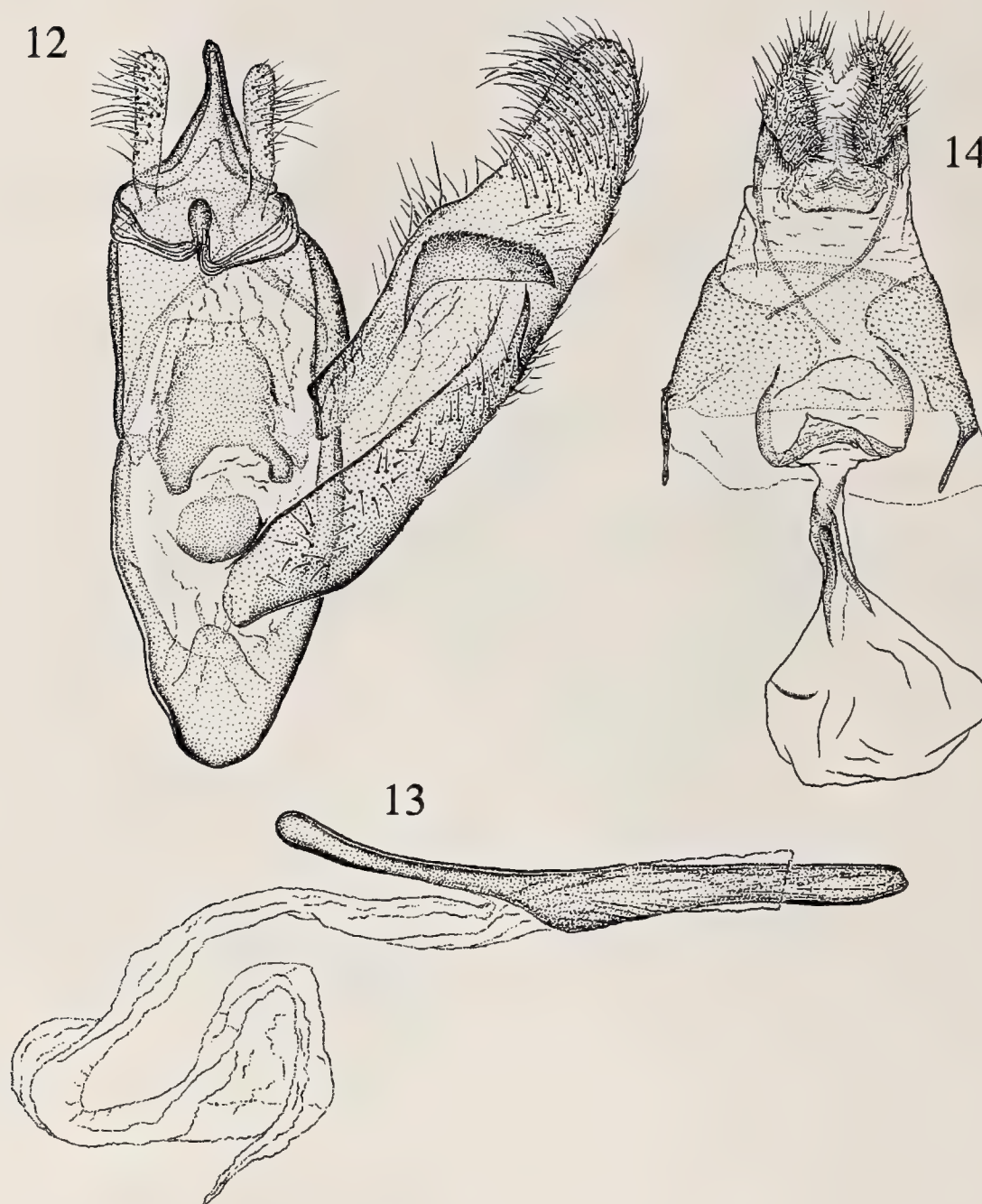
DIST: North America, throughout the Antilles, south to Argentina.

GUANA: 2 males, 1989.

BIO: Larvae on *Solanum nigrum* L., *Physalis* spp. (Solanaceae) (Poole et al. 1993).

COM: Easily confused with the tobacco budworm, *H. virescens* (Fabricius), not collected but certainly occurring on the island. Male *H. subflexa* have white hindwing, while in *H. virescens* they are bordered olive-gray. More details on both species can be found in Poole et al. (1993). Haile et al. (1975) discuss movement of *Heliothis* spp. among the Virgin Islands.





FIGS. 12–14. Genitalia of *Eucana simplaria*. 12, male, ventral view, left valva and aedeagus removed; 13, aedeagus, lateral view; 14, female, ventral view

#### Noctuinae

*Anicla infecta* (Ochsenheimer, 1816)  
(Fig. 17)

ID: Gray, with forewing reddish brown along external margin; hindwing hyaline. Recognized by blackish anterior border (patagia) of thorax.

DIST: Argentina through Central United States, including Galapagos and Bermuda.

GUANA: 6 specimens, 1986, 1989, 1990.

BIO: General feeder, cut worm. The larvae reach nearly 3 cm when fully grown. They are variable in color from gray to yellowish ferrugineous, olivaceous yellow and bright green, to a sordid brown, usually flecked with black.

COM: At least three other cut worms should be present in the island: *Agrotis ipsilon* (Hufnagel), *A. subterranea* (Fabricius) and *Peridroma saucia* (Hübner).

#### Hadeninae

*Leucania humidicola* Guenée, 1852  
(Fig. 19)

ID: Medium sized, pale moth. Distinguished from other noctuids on the island by its forewing pattern: a long dark dash delimited above by a white line, running from base to middle.

DIST: Antilles to Brazil and probably Galapagos; the limits of the distribution of the species remain to be determined (Adams 2001).





FIGS. 15–61. Natural size (1:1). Notodontidae (15) and Noctuidae (16–61) (species from Guana, unless stated otherwise). 15, *Nystalea nyseus*, male; 16, *Heliothis subflexa*, male (USA); 17, *Anicla infecta*, male; 18, *Leucania dorsalis*, female (Cuba); 19, *L. humidicola*, male; 20, *Neogalea sumia*, male; 21, *Catabenoides lazelli*, holotype male; 22, *C. terminellus*, female; 23, *Spodoptera albulum*, male; 24, *S. frugiperda*, female (Puerto Rico); 25, *S. frugiperda*, male (Brazil); 26, *S. latifascia*, male; 27, *S. latifascia*, female (Cuba); 28, *S. pulchella*, male; 29, *S. dolichos*, male (Mexico); 30, *Magusa orbifera*, female; 31, *Condica albiger*, male; 32, *C. albiger*, female; 33, *C. mobilis*, male (Brazil); *C. sutor*, male (Brazil); 35, *Perigea gloria*, holotype male; 36, *Elaphria agrotina*, male; 37, *E. nucicolora*, female; 38, *E. nucicolora*, male (Cuba); 39, *Micrathetis triplex*, female; 40, *M. triplex*, male; 41, *Bagisara repanda*, female; 42, *Amyra axis*, female; 43, *Ponometia exigua*, male; 44, *P. exigua*, female; 45, *P. exigua*, female (Mexico); 46, *Cydosis nobilitella*, male (Cuba); 47, *Caularis undulans*, male; 48, *Motya abseuzalis*, male; 49, *Collomena filifera*, male; 50, *C. filifera*, female (Cuba); 51, *Paectes obrotunda*, male; 52, *P. obrotunda*, female; 53, *Pseudoplusia includens*, female; 54, *Ptichodis immunis*, male (Cuba); 55, *P. immunis*, female; 56, *Mocis antillesia*, male; 57, *M. antillesia*, female; 58, *M. latipes*, male; 59, *M. repanda*, male (Cuba); 60, *M. repanda*, female (Puerto Rico); 61, *Ophisma tropicalis*, male.



GUANA: 2 specimens, 1989.

BIO: Hayes (1975) [as *L. solita*, see below] gives *Sporobolus virginicus* (L.) Kunth. (Poaceae) as food-plant.

COM: The Guana specimens were identified as *humidicola* by Morton S. Adams, who has subsequently published a revision of the group in the Caribbean (Adams 2001) although our specimens are not mentioned in his paper. The name *humidicola* (type-locality: FRENCH GUIANA) has been wrongly applied to a different species by most authors (see *dorsalis* below), following the misidentification by Hampson (1905). A specimen collected by the first author in COSTA RICA: Guanacaste, El Coco (VOB 33636), identical to those from Guana, matches the type of *solita* (type-locality: HONDURAS) in BMNH, and the specimen figured by Hayes (1975), from Galapagos. Therefore *L. solita* Walker 1856, **new synonym**, is a junior synonym of *humidicola*, not of *multilinea* Walker (sensu Hampson 1905, Poole 1989). We regard *multilinea* Walker 1856 as a valid species because we believe that Hayes (1975), who had the types of both *multilinea* and *solita* at hand, had good reasons to treat the latter as a valid species.

*Leucania dorsalis* Walker, 1856  
(Fig. 18)

ID: Easily confused with *L. humidicola*; dash along middle of forewing not as conspicuous.

DIST: Antilles, northern South America, Central America, and southern Florida (Adams 2001).

GUANA: 1 specimen, 1988.

BIO: Unknown; presumably grasses as for its close relatives *L. infatuans* Franclemont and *L. extenuata* Guenée.

COM: This species belongs to a complex previously treated as *humidicola*, following a misidentification by Hampson (1905). See Adams (2001:199) for further discussion of the species complex.

Amphipyriinae  
*Neogalea sunia* (Guenée, 1852)  
(Fig. 20)

ID: Medium sized, inconspicuous gray moth resembling *Spodoptera albulum*, but darker. Usually distinguished from *S. albulum* by the dark marked veins and, for males, by the abdomen thickly clothed with long scales.

DIST: Florida to Argentina, including Galapagos.

GUANA: 6 specimens, 1987, 1989, 1990.

BIO: Larvae on *Lantana* (Verbenaceae) (Comstock and Dammers 1935). Introduced to Hawaii and Australasia to control *Lantana* (Riotte 1991, Holloway 1996:148).

COM: Immature stages described by Comstock and Dammers (1935, as *Catabene esula*). Although this genus was placed in Cuculliinae by Poole (1989), we place it in Amphipyriinae following the comments by Todd (1972b) and Poole (appendix to this paper) placing it with *Catabena* and *Catabenoides*, which Poole (1989) placed as Amphipyriinae. The proper placement of many genera formerly associated with Amphipyriinae and Cuculliinae requires review.

*Catabenoides terminellus* (Grote, 1883), **new combination**  
(Figs. 2, 3, 22)

ID: This and the following species are closely related, almost impossible to distinguish with external characters (see *C. lazelli* below). They resemble small *S. albulum* but are distinguished from it by the gray, irregular dot on tornus of forewing. Females usually have a black line along middle, covering the length of the forewing.

DIST: Southern USA, Antilles.

GUANA: 4 specimens, 1984.

BIO: Unknown.

COM: In order to place this and the following species correctly, we include a description of the new genus *Catabenoides* by Robert Poole as an appendix to this paper.

*Catabenoides lazelli* Becker and Miller, **new species**  
(Figs. 4–6, 21)

**Description.** Light gray, 2.2–2.6 cm. This and the former are very closely related species, almost impossible to be distinguished from each other on external characters (see *terminellus* above). They resemble a small *S. albulum* but easily recognized from it by the gray, irregular dot on tornus of forewing. Females usually have a black line along middle, covering the whole extension of forewing. The only reliable external feature that distinguishes *lazelli* from *terminellus* is the color of patagia. In *terminellus* there is a transverse line of blackish scales, dividing the patagia along the middle, while in *lazelli* the line is ochreous. The genitalia are also distinct. In *terminellus* the distal processes of the sacculus are simple, nearly straight rods (Fig. 2), while those in *lazelli* are complex, branched (Fig. 4).

DIST: Guana, Anegada, St. Croix.

GUANA: 35 specimens, 1984, 1985, 1989, 1990.

MATERIAL EXAMINED: Holotype male: BVI: Guana Id., 1–14.vii.1984 (S. E. & P. M. Miller) (USNM). Paratypes: 13 males, 12 females: Same data as holotype (USNM, BMNH, BPBM, MCZ, VOB); 1



female: Same locality and collector, 5–23.vii.1985 (USNM); 2 males, 1 female: Same locality, x.1989 (V. O. Becker, 70710) (VOB); 2 males, 3 females: Same locality, 24.x–5.xi.1990 (S. E. Miller & T. M. Kuklenski) (BPBM). ANEGADA: 2 males, 1 female: 17–19.vii.1985 (S. E. & P. M. Miller) (USNM). ST. CROIX: 2 males, 2 females, Kingshill, x, xi.1944, v, vi.1945 (H. A. Beatty) (CU); 1 female, same locality, 6–16.vii.1967 (E. L. Todd) (USNM); 1 female, Christiansted, 19. xi.1941 (H. A. Beatty) (USNM); 1 male, 2 females, Mt. Eagle, 6–16.vii.1967 (E. L. Todd) (USNM); 4 males, 1 female, 1 mi W Airport, 6–16.vii.1967 (E. L. Todd) (USNM); 2 males, 1 female, Orangegrove, W End, 6–16.vii.1967 (E. L. Todd) (USNM); 1 male, Blue Mtn., 6–16.vii.1967 (E. L. Todd) (USNM); 2 males, Rust Up Twist, 6–16.vii.1967 (E. L. Todd) (USNM); 1 male, 1 mi N Great Pond, 6–16.vii.1967 (E. L. Todd) (USNM). BIO: Unknown.

COM: This species belongs to a complex formerly considered the single species, *C. vitrinus* (Walker), a species not found in the Lesser Antilles. The genitalia of *C. lazelli* (Fig. 4, 5) are very similar, but show consistent differences, the most evident is the vesica armed with a single, strong cornutus, whereas in *vitrinus* the vesica bears a series of smaller cornuti. The complex will be treated in a forthcoming revision (Becker in prep.). This species is dedicated to our friend Dr. James “Skip” Lazell, who gave us the opportunity to study this interesting fauna.

*Spodoptera albulum* (Walker, 1857)  
(Fig. 23)

ID: Plain, pale gray, medium sized species, readily distinguished by the presence, on the forewing, of a very fine black line running along the middle from base to one-fourth. Hindwing almost totally translucent whitish. DIST: United States, throughout the Antilles, south to Argentina, but not including Galapagos and Bermuda. GUANA: 5 specimens, 1989, 1990.

BIO: Larvae on *Amaranthus* sp. (Amaranthaceae) (Kimball 1965) and cotton (Bruner et al. 1975). Recorded from many crops in Puerto Rico by Armstrong (1994a).

COM: “This is the species previously identified as ‘*Spodoptera sunia* Guenée’. The real *Xylopermyges sunia* Guenée 1852 is actually the species [formerly] known as *Neogalea esula* Druce” (Poole 1989) (see *N. sunia* above). *Spodoptera albulum* is easily confused with *S. eridania*, which has not been collected on Guana, but is likely to occur on the island. *Spodoptera eridania* is dusted brownish, and lacks the forewing line mentioned above. Todd and Poole (1980) give an

illustrated key to the New World species of *Spodoptera* and distributions of *Spodoptera* species in the Caribbean are reviewed in Cock (1985:92).

*Spodoptera frugiperda* (J. E. Smith, 1797)  
(Fall armyworm)  
(Figs. 24, 25)

ID: Medium sized, sexually dimorphic, gray species. Males have an oblique whitish dash from middle of costa across the cell. Females have indistinct pattern, looking almost plain gray.

DIST: Widespread in New World, including Galapagos and Bermuda.

GUANA: 8 specimens, 1986, 1990.

BIO: Polyphagous on herbaceous plants and regarded as a serious pest of maize and other crops (Andrews 1980). In Puerto Rico, it has been recorded as a pest of various crops (Armstrong 1994b) and *Eucalyptus* seedlings (Myrtaceae) (Torres 1994).

*Spodoptera latifascia* (Walker, 1856)  
(Figs. 26, 27)

ID: Medium sized, sexually dimorphic species. Male forewing with a diffuse pattern of reddish brown and gray on a whitish gray background. Female forewing darker, easily confused with *S. dolichos* and bearing an oblique elongate whitish mark from middle costa to end of cell, followed by three short whitish lines along veins.

DIST: Gulf States of the United States, throughout the Antilles, south to Costa Rica. The population from Costa Rica south to Argentina, previously included under *S. latifascia*, belongs to *S. cosmioides* (Walker), a closely related but distinct species (Silvain & Lalanne-Cassou 1997, M. Pogue pers. com.).

GUANA: 1 specimen, 1989.

BIO: Polyphagous on herbaceous plants, sometimes becoming a pest of vegetables and nursery seedlings.

*Spodoptera pulchella* (Herrich-Schäffer, 1868)  
(Fig. 28)

ID: Wing pattern similar in both sexes; easily confused with the females of the former. It can be separated from similar species by the curved whitish line along dorsum, below the anal vein, from basal fourth to just before tornus.

DIST: Florida, Greater Antilles.

GUANA: 1 specimen, 1989.

BIO: Unknown.

COM: This seems to be the first record of this species to the Puerto Rican Bank. It has either been overlooked because of rarity, or because it was mistaken for the similar *S. latifascia*, a more common species.



*Spodoptera dolichos* (Fabricius, 1794)

(Fig. 29)

ID: About the same size as *S. latifascia*; both sexes showing similar pattern to that of female *S. latifascia*. Easily distinguished from the previous two species by the two conspicuous, parallel, dark gray bands along thorax.

DIST: Sympatric with *S. latifascia*, including in Galapagos.

GUANA: 1 specimen, 1989.

BIO: Larvae on a wide variety of plants, both crops and weeds (Ferguson et al. 1991).

*Magusa orbifera* (Walker, 1857)

(Fig. 30)

ID: An extremely polymorphic, medium sized (3–4 cm), gray to brown species. In the Guana population, some males have a wide pale area along dorsum of forewing, others have a very complex and contrasting maculation, while the females tend to be less marked and more brownish. One constant feature is the conspicuous round pale dot near the apex of forewing and the very broad dark fuscous hindwing. *Anateinoma affabilis* and *E. agrotina* also have the pale mark at end of apex of forewing but are at most half the size of *M. orbifera*.

DIST: Widespread throughout the New World, from Canada to Argentina (not reported from Galapagos, but *M. erema* Hayes (1975) may be a local variety of this species).

GUANA: 57 specimens, 1989, 1990.

BIO: Larvae on various legumes, including *Karwinskia* and *Condalia* (Fabaceae) (Kimball 1965).

*Condica albiger*a (Guenée, 1852)

(Figs. 31, 32)

ID: Medium sized (2.5–3 cm wing span), dark fuscous; forewing with an irregular small white dot at end of cell, followed by a paler, almost straight transverse line.

DIST: Mexico, throughout Antilles, south to Paraguay.

GUANA: 3 specimens, 1989, 1990

BIO: Unknown.

COM: Easily confused with *C. circuita* (Guenée), not collected but likely to occur on the island. In *C. circuita* the white dot on forewing is round and has a white lunule just under it.

*Condica mobilis* (Walker, [1857])

(Fig. 33)

ID: About same size as *C. albiger*a, but more reddish brown and orange; white dot on cell usually larger than in *C. albiger*a.

DIST: Southern United States, throughout Antilles, south to Argentina.

GUANA: 1 specimen, 1989.

BIO: Unknown.

COM: Commonly referred to in the literature as *Perigea apameoides* Guenée, which is a synonym of *C. sutor* (Guenée) (Hayes 1975).

*Condica sutor* (Guenée, 1852)

(Fig. 34)

ID: Same size as *C. albiger*a and *C. mobilis*; fuscous with forewing showing little contrasting pattern. Distinguished from *albiger*a and *mobilis* by the absence of the whitish mark on cell.

DIST: Southern United States, throughout the Antilles, south to Argentina, including Galapagos.

GUANA: 1 specimen, 1990.

BIO: Larvae on several species of herbaceous plants including *Wedellia*, *Tagetis* (Asteraceae), and celery (Kimball 1965).

***Perigea gloria* Becker and Miller, new species**

(Figs. 7–9, 35)

**Description.** Medium sized (3 cm wing span), pale moth; forewing shaded dark fuscous, with a series of small dark marks along costa and small black dots along termen, in the spaces between veins. Similar to *C. sutor* but with more contrasting pattern, and readily separated by the series of black dots along termen.

DIST: Guana, Tortola.

GUANA: 2 specimens, 1989.

MATERIAL EXAMINED: Holotype male: BVI: Guana Id., x.1989 (V. O. Becker, 70722) (USNM); Paratypes, 1 female, same data as holotype (VOB); 1 male Tortola, Mt. Sage, 460m, 13–15.vii.1987 (V. O. Becker & S. E. Miller, 66865) (VOB).

BIO: Unknown.

COM: Very similar in appearance to *P. berinda* (Druce), a species from the Greater Antilles and Central America, but with genitalia (Figs. 7–9) very different from those of *berinda*, being very similar to those of *P. glaucoptera* (Guenée). This species is dedicated to Ms. Gloria Jarecki, for her and her family's support of The Conservation Agency's biodiversity research on Guana Island over the years.

*Elaphria agrotina* (Guenée, 1852)

(Fig. 36)

ID: Small (2–2.5 cm wing span); forewing dark fuscous with a paler area along costa and a conspicuous pale dash near apex. Similar to *A. affabilis* (see below), but larger and with hindwing bordered whitish.

DIST: Florida, throughout the Antilles, south to Argentina.



GUANA: 5 specimens, 1987, 1989, 1990.

BIO: Larvae on cotton and beans (*Phaseolus*) (Fabaceae) (Silva et al. 1968).

*Elaphria nucicolora* (Guenée, 1852)  
(Figs. 37, 38)

ID: Same size as *E. agrotina*; forewing dark fuscous, with a broad, ill-defined, darker triangular mark with base on middle of dorsum and vertex at end of cell. Hindwing whitish.

DIST: Throughout New World tropics including Bermuda. Immigrant to Hawaii.

GUANA: 1 specimen, 1989.

BIO: Larvae on various herbaceous plants (Ferguson et al. 1991).

*Anateinoma affabilis* Möschler, 1890  
(Figs. 10, 11, 151, 152)

ID: Small (15 mm wing span); forewing reddish brown with transverse sinuate lines alternating pale and dark, and with a conspicuous whitish dash on apex. Similar to *E. agrotina* (see above) but smaller, and forewing lacking pale area along costa. *Magusa orbifera* also has a pale mark on apex, but is almost three times the size of *affabilis*.

DIST: Puerto Rico and Virgin Islands.

GUANA: 22 specimens, 1987, 1989, 1990.

BIO: Unknown.

COM: Despite the accurate color illustration presented by Möschler (1890), who described this species from Puerto Rico, Hampson (1910) treated *A. affabilis* as an unrecognized taxon in the *Erastrinae* [=Acontiinae], where it has remained. One of the reasons for this situation is because no material except for the types, which are supposed to be in MNHU, Berlin, has been available to subsequent authors working on the New World noctuid fauna. No material of this species was found in the BMNH or USNM; for this reason vouchers from the series studied here have been deposited there.

This species does not belong in Acontiinae, but is related to some species currently placed in *Elaphria* Hübner. However, at present we prefer not to synonymize *Anateinoma* under *Elaphria* as the group needs revision. The male genitalia is illustrated in Figs. 10, 11.

*Micrathetis triplex* (Walker, 1857)  
(Figs. 39, 40)

ID: Small (1.5–2.2 cm wing span), slightly dimorphic, variable in color. Males have pale forewing speckled with darker small dots, termen dark brown, and a conspicuous dark brown dot at end of cell. Females are

darker than males. Hindwing whitish, slightly bordered with dark gray. Easily recognized by the dot at the end of the cell and by the two rows of small blackish dots forming two arches, almost parallel to each other, from costa to dorsum.

DIST: Southern United States through South America.

GUANA: 14 specimens, 1987, 1989, 1990.

BIO: Unknown.

Agaristinae

*Caularis undulans* Walker, [1858]  
(Fig. 47)

ID: Undoubtedly the most attractive noctuid on the island. Forewings white bordered and marked olive; hindwing golden yellow bordered reddish-brown with a lunular blackish mark on tornus. Male genitalia illustrated by Kiriakoff (1976).

DIST: Hispaniola, Jamaica, Puerto Rican Bank (Kiriakoff 1976).

GUANA: 9 specimens, 1989.

BIO: Unknown.

Bagisarinae

*Bagisara repanda* (Fabricius, 1793)  
(Fig. 41)

ID: Small, 2–2.5 cm wing span, pale yellow, dusted gray. Easily identified by the three pale lines crossing the forewing, more or less equidistant, parallel to each other, and bent basad near costa.

DIST: Widespread from Southeast United States to Paraguay, including Galapagos (Hayes 1975, Ferguson 1997).

GUANA: 4 specimens, 1987, 1989.

BIO: Larvae on *Sida glomerata* Cav. (Malvaceae) (Hayes 1975).

COM: Very common in disturbed areas where malvaceous weeds often occur.

Acontiinae

*Amyna axis* (Guenée, 1852)  
(Fig. 42)

ID: Small, fuscous species, easily confused with some small *Condica* species. Males are distinguished from *Condica* by the presence of a round, semitranslucent area near base of forewing.

DIST: Pantropical, including Tahiti and Hawaii.

GUANA: 2 specimens, 1989.

BIO: Larvae on *Chenopodium* (Chenopodiaceae), *Cardiospermum* (Sapindaceae), *Parasponia* (Ulmaceae), and *Amaranthus* (Amaranthaceae) (Ferguson 1991).

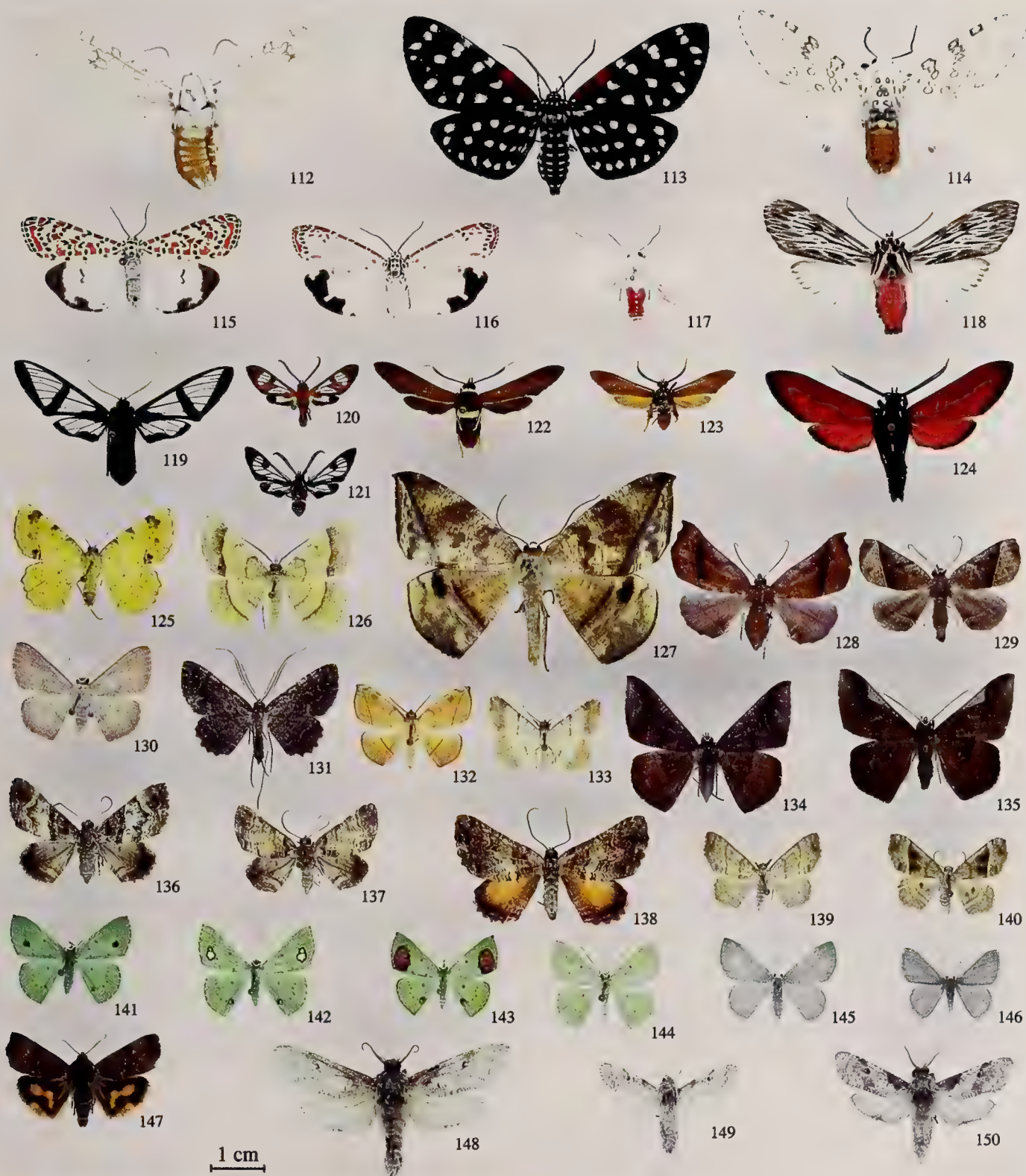
COM: The large distribution and obscure pattern have contributed to long synonymy: it has been described





FIGS. 62–111. Natural size (1:1). Noctuidae (specimens from Guana, unless stated otherwise). 62, *Azeta versicolor*, male; 63, *A. versicolor*, female; 64, 65, *Metallata absumens*, males; 66, *M. absumens*, male; 67, *Plusiodonta thomae*, male; 68, *Syllectra erycata*, male (Cuba); 69, *Litoprosopus puncticosta*, male; 70, *Diphthera festiva*, male; 71, *Gonodonta bidens*, male (Puerto Rico); 72, *Melipotis acontoides*, female; 73, *M. fasciolaris*, male; 74, *M. fasciolaris*, female; 75, *M. contorta*, male; 76, *M. famelica*, male; 77, *M. ochrodes*, male; 78, *M. ochrodes*, female (Puerto Rico); 79, *M. januaris*, male (Cuba); 80, *M. januaris*, female (Cuba); 81, *Epidromia lienaris*, male (Puerto Rico); 82, *Ephyrodes cacata*, male (Cuba); 83, *E. cacata*, female; 84, *Concana mundissima*, female; 85, *Massala asema*, male; 86, *Manbuta pyraliformis*, male (Cuba); 87, *Lesmone hinna*, male (Cuba); 88, *L. hinna*, female (Cuba); 89, *L. hinna*, male; 90, *L. formularis*, male; 91, *L. formularis*, female (Cuba); 92, *Baniana relapsa*, male; 93, *B. relapsa*, female; 94, *Eulepidotis modestula*, male (Cuba); 95, *E. addens*, female; 96, *Toxonprucha diffundens*, male (Mexico); 97, *Kakopoda progenies*, male; 98, *Parachabora abydas*, male; 99, *Cecharismena abarusalis*, male; 100, *C. cara*, male; 101, *Glympis eubolialis*, male; 102, *Drepanopalpia lunifera*, male (Cuba); 103, *D. lunifera*, female; 104, *Lascoria orneodalis*, female; 105, *L. orneodalis*, male (Cuba); 106, *Bleptina caradrinalis*, male; 107, *B. caradrinalis*, female; 108, *B. hydrillalis*, male; 109, *B. menalcasalis*, female; 110, *B. menalcasalis*, male; 111, *Hypena lividalis*, female.





FIGS. 112–150. Natural size (1:1). Arctiidae (112–124), Geometridae (125–146), Cossidae (147–149) and Hyblaeidae (150) (specimens from Guana, unless stated otherwise). **112**, *Hypercompe simplex*, male (Puerto Rico); **113**, *Composia credula*, male; **114**, *H. simplex*, female; **115**, *Calidota strigosa*, male; **116**, *Eupseudosoma involutum*, male (Puerto Rico); **117**, *Utetheisa ornatrix*, male; **118**, *U. pulchella*, female (Brazil); **119**, *Empyreuma pugione*, male; **120**, *Horama panthalon*, male; **121**, *H. pretus*, male; **122**, *Cosmosoma achemon*, male (St. Thomas); **123**, *Eunomia colombina*, male; **124**, *Nyridela chalciope*, female (Cuba); **125**, *Pero rectisectaria*, male; **126**, *P. rectisectaria* female; **127**, *Oxydia vesulia*, male; **128**, *Erastria decrepitaria*, male (Cuba); **129**, *E. decrepitaria*, female; **130**, *Sphacelodes fusilineatus*, male; **131**, *S. fusilineatus*, female; **132**, *Macaria paleolata*, male; **133**, *Patalene ephyrata*, male; **134**, *Almodes terraria*, male (Bahamas); **135**, *Semaepus malefidarius*, male; **136**, *Leptostales noctuata*, male; **137**, *L. noctuata*, female; **138**, *Obila praecurraria*, female (Tortola); **139**, *Pterocypha defensata*, male; **140**, *P. defensata*, female; **141**, *Eueana simplaria* male; **142**, *E. simplaria* female; **143**, *Phrudocentra centrifugarium*, male; **144**, *P. centrifugarium*, female (Cuba); **145**, **146**, *P. centrifugarium*, females; **147–149**, *Psychonoctua personalis*, males; **150**, *Hyblaea puera*, male (Cuba).



18 times (Poole 1989). Frequently referred to in the literature as *A. octo* (Guenée), a synonym based on the priority of names established by Nielsen et al. (1996: note 690).

*Ponometia exigua* (Fabricius, 1793)  
(Figs. 43–45)

ID: Small, variable, sexually dimorphic species; males pale yellow with forewing crossed with diffuse, sinuate olivaceous bands. Female forewing dark fuscous with a wide, contrasting, pale fascia along costa. In some females this pattern is less contrasting.

DIST: Southern United States, throughout the Antilles, south to Brazil, including Galapagos.

GUANA: 9 specimens, 1989, 1990.

BIO: Larvae on *Waltheria ovata* Cav. (Sterculiaceae) (Hayes 1975).

COM: Commonly referred to in the literature by its junior synonym *P. indubitans* (Walker).

*Cydosia nobilitella* (Cramer, 1779)  
(Fig. 46)

ID: Small showy moth; one of the most attractive noctuids on the island. Forewing with reticulated pattern with white areas enclosed by dark bluish metallic gray and red lines. Hindwing semitranslucent white in males, dark gray in females. Pattern resembles some species of *Atteva* (Yponomeutidae) and specimens are often found mixed in collections.

DIST: Southern United States, throughout Antilles, south to Argentina.

GUANA: 1 specimen, 1984.

BIO: Hampson (1910) mentioned “?*Spigelia an-thelmia* L.” (Loganiaceae) as hostplant, following Cockerell (1897). No species of this plant family known from the island (G. Proctor pers. com.), although the species occurs on other Virgin Islands (Acevedo-Rodriguez 1996). Cockerell (1897) and Dyar (1897) described the larvae.

*Tripudia quadrifera* (Zeller, 1874)  
(Figs. 153, 154)

ID: The smallest noctuid on the island (0.7–1.2 cm wing span); resembling Olethreutinae (Tortricidae) and *C. metaspilaris* (see below). Dark gray; forewing with conspicuous quadrate mark on middle of dorsum.

DIST: Southern United States, throughout the Antilles, south to Brazil.

GUANA: 22 specimens, 1989, 1990.

BIO: Unknown.

*Tripudia balteata* Smith, 1900  
(Fig. 155)

ID: Small, on average slightly larger than *T. quadrifera*. Dark gray. Easily identified by the broad, oblique, yellowish band on forewing.

DIST: Southern United States, Antilles, south to Brazil.

GUANA: 16 specimens, 1987, 1989, 1990.

BIO: Unknown.

*Ommatochila mundula* (Zeller, 1872)  
(Fig. 156)

ID: Small, 1.5–2 cm wing span, dark gray, resembling some Olethreutinae species (Tortricidae). Forewing divided across the middle by a pale, almost straight line, the basal half much darker than outer half.

DIST: Southern United States, Antilles, south to Argentina.

GUANA: 14 specimens, 1986, 1989, 1990.

BIO: Unknown.

*Cobubatha metaspilaris* Walker, 1863  
(Fig. 157)

ID: Small, 1.5 cm wing span, gray; similar to, but larger than *T. quadrifera*. In the latter the mark on dorsum is quadrate whereas in *metaspilaris* it is trapezoidal.

DIST: Antilles.

GUANA: 3 specimens, 1990.

BIO: Unknown.

*Eumicremma minima* (Guenée, 1852)  
(Fig. 158)

ID: Very small (1.2–1.5 cm wing span); forewing pale, crossed with olive and dark olive waiving bands, and with some very small, black dots along termen, the most conspicuous the one near apex and the other near tornus. In resting posture it looks like some species of Cochylini (Tortricidae).

DIST: Southern United States, Antilles, south to Argentina.

GUANA: 3 specimens, 1987.

BIO: Larvae on *Gnaphalium* (Asteraceae).

*Eublemma rectum* (Guenée, 1852)  
(Fig. 161)

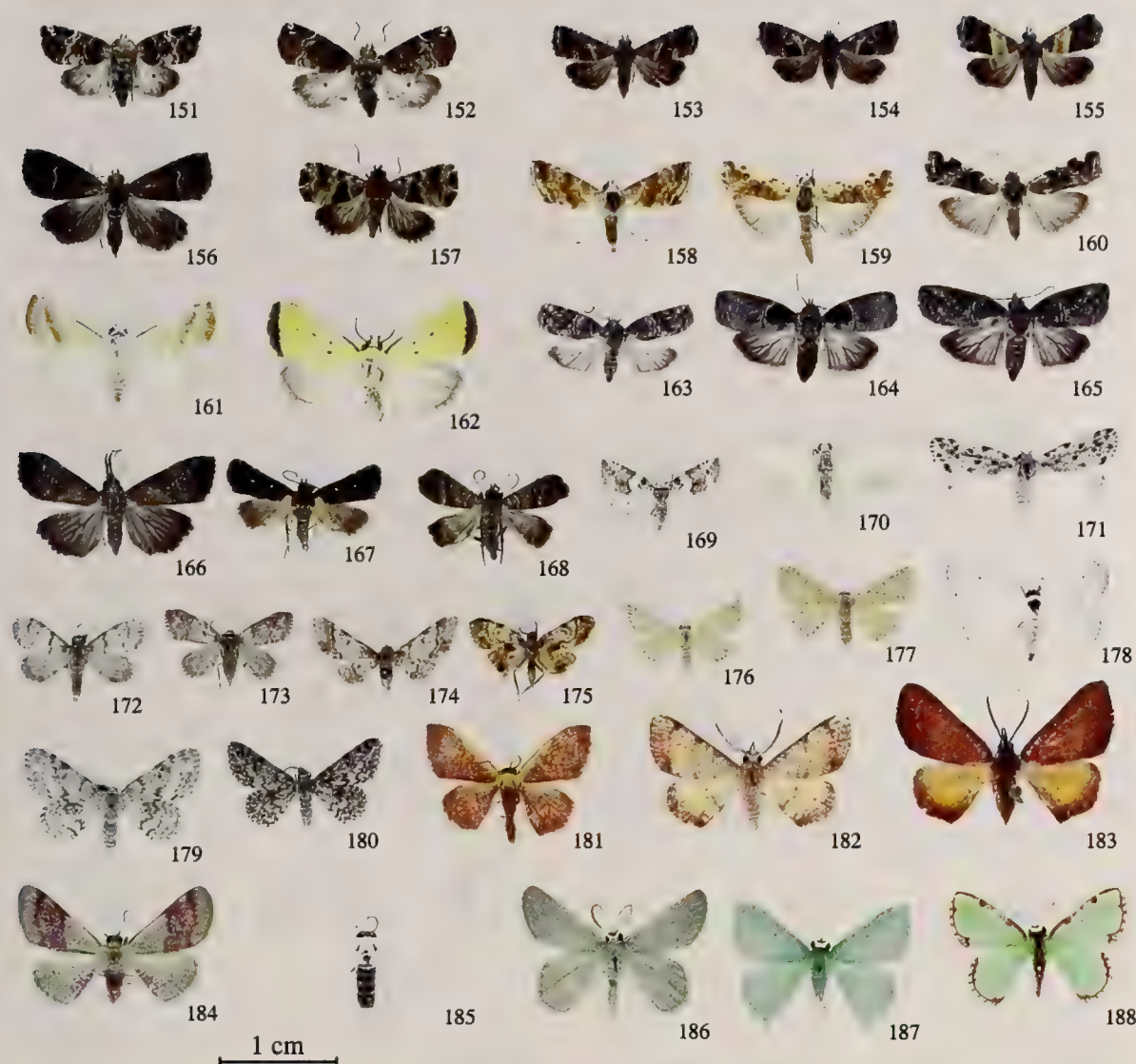
ID: Small, 1.5 cm wing span; pale yellow; forewing clouded with red brown with oblique pale fascia from middle of dorsum to near apex.

DIST: Southern United States, throughout the Antilles, south to Argentina, including Galapagos and Bermuda.

GUANA: 3 specimens, 1989.

BIO: Larvae on *Ipomoea* and *Convolvulus* (Convolvu-





Figs. 151–188. Twice natural size (2:1). Noctuidae (151–168), Arctiidae (169–171) and Geometridae (172–188) (specimens from Guana, unless stated otherwise). **151, 152**, *Anateinoma affabilis*, males; **153**, *Tripudia quadrifera*, female (Mexico); **154**, *T. quadrifera*, female; **155**, *T. balteata*, male; **156**, *Ommatochila mundula*, female; **157**, *Cobubatha metaspilaris*, male; **158**, *Eumicremma minima*, male (Cuba); **159**, *Spragueia margana*, male, (Brazil); **160**, *S. margana*, female (Brazil); **161**, *Eublemma rectum*, male; **162**, *Thioptera aurifere*, male (Brazil); **163**, *Characoma nilotica*, female; **164, 165**, *C. nilotica*, females (Mexico); **166**, *Hypena minualis*, female; **167**, *Bleptina araealis*, male; **168**, *B. araealis*, female; **169**, *Afrida charientisma*, male; **170**, *Progonia pallida*, male; **171**, *Lomuna nigripuncta*, female; **172**, *Idaea monata*, male; **173**, *Idaea monata*, female; **174**, *Idaea eupitheciata*, female; **175**, *I. eupitheciata*, male; **176**, *I. minuta*, male; **177**, *I. minuta*, female; **178**, *Scopula laresaria*, female; **179, 180**, *Idaea* probably *fernaria*, females; **181**, *Leptostales phorcaria*, male; **182**, *Cyclomia mopsaria*, male; **183**, *C. mopsaria*, female; **184**, *Leptostales oblinataria*, female; **185**, *Acratodes suavata*, male; **186**, *Chloropteryx paularia*, male; **187**, *Synchlora frondaria*, male; **188**, *S. cupedinaria*, male.

laceae) (Forbes 1954) [as *E. obliqualis* (Fabricius), a homonym].

*Spragueia margana* (Fabricius, 1794)  
(Figs. 159, 160)

ID: The smallest of the two *Spragueia* species on the island; dimorphic. Similar to *S. perstructana* (see below). Males easily distinguished from the latter by the absence of orange, by the pale costa, and by the olivaceous shades and marks on forewing; females by the olivaceous thorax, which is edged pale yellow in *S. perstructana*.

DIST: Southern United States, throughout the New World tropics, including Galapagos.

GUANA: 4 specimens, 1987.

BIO: Larvae on *Abutilon* and *Sida* (Malvaceae) (Hayes 1975).

*Spragueia perstructana* (Walker, 1865)

ID: Similar to, but slightly larger than *S. margana* (see above); also dimorphic. Illustrated in color in Kimball (1965: Pl. IV, figs. 31, 37).

DIST: Southern United States, Antilles, south to Costa Rica.



GUANA: 1 specimen, 1989.

BIO: Unknown.

*Thioptera aurifere* (Walker, [1858])  
(Fig. 162)

ID: Small, 1.5–1.8 cm wing span; yellow; forewing usually with two very small black dots, an ill defined reddish line beyond the cell from costa to dorsum, and termen edged with gray.

DIST: Southern United States, throughout Antilles, south to Brazil.

GUANA: 4 specimens, 1989, 1990.

BIO: Unknown, however Kimball (1965) gives *Digitaria ischaemum* [*Syntherisma impomoea*] (Poaceae) as the food plant for *T. nigrofimbria*, a closely related species.

Sarothripinae

*Characoma nilotica* (Rogenhofer, 1882)  
(Figs. 163–165)

ID: Small, 1–1.2 cm wing span, highly variable, gray species. Rests flat, looking like some tortricids.

DIST: Described from Egypt, hence its name; now Pantropical, including Galapagos, Bermuda, and the Pacific Islands.

GUANA: 25 specimens, 1985, 1986, 1990.

BIO: Larvae on white mangrove, *Laguncularia racemosa* (L.) C.F. Gaertn. (Combretaceae) (Hayes 1975); willow, almond, azalea, and “black olive” (Ferguson 1991).

*Collomena filifera* (Walker, 1857)  
(Figs. 49, 50)

ID: Medium sized gray species, similar to female *S. frugiperda*. Distinguished by the whitish diffused band across the subterminal area of forewing and by the entirely whitish, semitranslucent hindwing (narrowly bordered gray in females).

DIST: Florida, throughout the Antilles, south to Brazil.

GUANA: 4 specimens, 1989, 1990.

BIO: Unknown.

*Motya abseuzalis* Walker, 1859  
(Fig. 48)

ID: Slightly smaller than *C. filifera*; whitish gray. Easily recognized by the two, almost parallel, rows of small, black dots along termen, with the one near tornus conspicuously larger. The male abdomen has two paired black dots dorsally, near apex. Hindwing semitranslucent white, bordered gray.

DIST: Florida, throughout the Antilles, south to Brazil.

GUANA: 1 specimen, 1989.

BIO: Unknown.

Euteliinae

*Paectes obrotunda* (Guenée, 1852)  
(Figs. 51, 52)

ID: Medium sized, gray, irrorated brown; males have basal half of antennae strongly pectinate, and long slim abdomen; females have filiform antennae and short stout abdomen. Forewing with a conspicuous pale lunular mark near base, delimited externally by a narrow, double line.

DIST: Southern United States, throughout Antilles, south to Paraguay.

GUANA: 64 specimens, 1984, 1987, 1988, 1989, 1990.

BIO: Unknown, however, its larvae should be searched for on *Bursera simaruba* (L.) Sarg. (Simarubaceae), as a related species, *P. arcigera* (Guenée), was reared on *B. graveolens* (Kunth) Triana & Planch. in Galapagos (Hayes 1975).

Plusiinae

*Pseudoplusia includens* (Walker, [1858])  
(Fig. 53)

ID: Medium sized, grayish brown with bronze luster. Recognized by the small silver markings near center of forewing.

DIST: United States to northern Chile and Argentina, including Galapagos and Bermuda (Lafontaine & Poole 1991:50).

GUANA: 2 specimens, 1989.

BIO: Polyphagous; Ferguson et al. (1991) lists plants belonging to 14 families as foodplants. Can be a minor pest of beans, soy beans, and other leguminous crops.

COM: Generally referred to in the literature as *P. oo* (Cramer), a homonym. Other species belonging to this subfamily, such as *Trichoplusia ni* (Hübner) and *Argyrogramma verruca* (Fabricius), are likely to be collected on the island in the future. These also bear silver marks on the forewing.

Catocalinae

*Ptichodis immunis* (Guenée, 1852)  
(Figs. 54, 55)

ID: Medium sized, 2.5–3 cm wing span, pale species. Forewing crossed with ill defined olivaceous lines, two of them highly contrasting: the antemedial and the postmedial, both bordered internally with lemon yellow.

DIST: Mexico, throughout the Antilles to Brazil.

GUANA: 6 specimens, 1987, 1989, 1990.

BIO: Unknown.



*Mocis latipes* (Guenée, 1852)  
(Fig. 58)

ID: Medium sized, 3.5–4 cm wing span, broad winged, dark species. Highly variable in color and pattern. Ground color varies from pale brownish through fuscous to reddish brown. Females tend to have pattern less contrasting than males, and the paler forms could easily be confused with the darker forms of female *M. disseverans*, a Neotropical species recorded from the Greater Antilles. Smaller than *M. repanda* (see below). The males of the species belonging to this genus can be easily distinguished from other noctuids by the thickly hairy hind legs.

DIST: Southern United States, throughout the Antilles, south to Argentina, including Galapagos and Bermuda.

GUANA: 1 specimen, 1989.

BIO: Larvae on several species of grasses, sometimes a pest of grazing land.

COM: Generally referred to in the literature as *M. repanda*, a different species (see below).

*Mocis antillesia* Hampson, 1913  
(Figs. 56, 57)

ID: Same size and easily confused with *M. latipes*. Ground color pale brownish to pale yellow. Clothing of hind legs usually yellowish in this whereas grayish in *M. latipes*. Smaller than *M. repanda* (see below).

DIST: Lesser Antilles, Bahamas.

GUANA: 4 specimens, 1989, 1990.

BIO: Unknown.

*Mocis repanda* (Fabricius, 1794)  
(Figs. 59, 60)

ID: Larger than the former two species in the genus, 4.5–5.5 cm wing span. Smaller specimens of this species are larger than the largest specimens of both *M. latipes* and *M. antillesia*. Distinguished from congeners by shape of postmedial lines in both wings: in the forewing it is bent inwards after the angle near costa, and fades away before tornus, whereas in the former two it is straight and reaches tornus; in the hindwing it is strongly angled outwards before tornus whereas in the others it is straight.

DIST: Antilles and Guatemala.

GUANA: 2 specimens, 1987, 1990.

BIO: Larvae on *Mucuna deeringiana* (Bort) Merr. [as *M. megas*] (Fabaceae) (Martorell 1976).

COM: Generally known in the literature as *M. megas* (Guenée), a junior synonym (Poole 1989). Berio (1953) clarified the status of *M. repanda* and illustrated the male genitalia.

*Ophisma tropicalis* Guenée, 1852  
(Fig. 61)

ID: Same size as *M. repanda*, but with stouter body. Extremely variable in pattern and color. Recognized by the small, conspicuous white dot on base of forewing.

DIST: Southern United States, throughout the Antilles, south to Argentina.

GUANA: 2 specimens, 1987.

BIO: Larvae on *Cupania americana* L. (Sapindaceae) (Martorell 1976).

Ophiderinae

*Azeta versicolor* (Fabricius, 1794)  
(Figs. 62, 63)

ID: Medium sized, polymorphic species; ground color varies from ferrugineous to dark grayish brown. Recognized by the pointed forewing and transverse pale dash at middle of forewing costa.

DIST: Throughout the New world tropics from Florida to Argentina.

GUANA: 23 specimens, 1987, 1989, 1990.

BIO: Larvae on *Canavalia* (Fabaceae) (Kimball 1965).

COM: Commonly referred to in the literature by its junior synonym, *A. repugnalis* (Hübner).

*Metallata absumens* (Walker, 1862)  
(Figs. 64–66)

ID: Medium sized, highly variable species. Ground color varies from reddish brown to gray. Similar to *E. cacata* but readily separated by the dark brown head and anterior border of thorax, by the nearly rounded border of hindwing, and by the filiform antennae in both sexes. Some specimens bear a black reniform mark at the end of forewing cell.

DIST: Southern United States, throughout the Antilles, south to Brazil, including Galapagos.

GUANA: 12 specimens, 1987, 1989, 1990.

BIO: Unknown.

*Plusiodonta thomae* (Guenée, 1852)  
(Fig. 67)

ID: Medium sized, dark brown species with some shining golden areas on forewing. Recognized by the single dentate expansion on middle of dorsum of forewing.

DIST: Described from St. Thomas, considered endemic to the Antilles.

GUANA: 4 specimens, 1987, 1989.

BIO: Unknown.

COM: It is very likely that the continental species, *P. clavifera* (Walker), is conspecific with *P. thomae*. There



is some degree of variation in both the Antillean and the continental populations, and specimens from both regions intergrade into each other. *Plusiodonta clavifera* has been reported from Galapagos (Hayes 1975).

*Syllectra erycata* (Cramer, 1780)  
(Fig. 68)

ID: Medium sized, reddish ferrugineous species. Forewing with three transverse lines, angled basad near costa, and with one or two small, round pale dots on outer side of postmedial line. Males distinguished by unique shape of antenna, which is uncommonly thick throughout its length except for the tip.

DIST: Florida, throughout the Antilles, south to Brazil.

GUANA: 3 specimens, 1986, 1987.

BIO: Unknown.

*Litoprosopus puncticosta* Hampson, 1926  
(Fig. 69)

ID: Large, velvet fuscous species. The narrow wings and stout body resemble a small sphingid. Readily distinguished from other noctuids of same size on the island by the orbicular black mark at lower edge of hindwing.

DIST: Haiti, Virgin Islands.

GUANA: 1 specimen, 1989.

BIO: Unknown, however, a close relative, *L. futilis* (Grote & Robinson), has been found boring into the flower stalks of *Sabal* and *Serenoa* (Arecaceae) (Ferguson et al. 1991).

*Diphthera festiva* (Fabricius, 1775)  
(Fig. 70)

ID: Medium sized, bright yellow, with an elaborate pattern of bluish gray lines and three parallel rows of dots parallel to external margin. Hindwing dark gray with pale cilia.

DIST: Widespread throughout the New World tropics, from Florida to Argentina.

GUANA: 2 specimens, 1987, 1989.

BIO: Larvae on *Casuarina equisetifolia* L. (Casuarinaceae), *Corchorus hirsutus* L. (Tiliaceae), *Schrankia portoricensis* Urb. (Fabaceae), and *Waltheria indica* L. (Sterculiaceae) (Martorell 1976, Torres 1994). Bright colored larvae reared in Brazil on *Sida* sp. (Malvaceae) (VOB), a common weed in disturbed areas on the island. COM: Referred to as *Noropsis hieroglyphica* (Cramer), the junior synonym, in older literature. Its pattern may be aposematic. One male was tossed towards a gray kingbird, *Tyrannus dominicensis* (Gmelin), who caught it in the air, returned to its perch, tried to swallow the

moth, then spit it out and cleaned its beak against the branch (VOB pers. obs.).

*Gonodonta bidens* Geyer, 1832  
(Fig. 71)

ID: Showy, medium sized moth; cannot be confused with any other species on the island. Forewing velvet dark brown; basal and postmedial areas paler, crossed with waving dark and reddish brown lines. Hindwing dark gray with a bright elongate yellow area at middle. Head conspicuously white.

DIST: Florida, throughout the Antilles, south to Argentina.

GUANA: 1 specimen, 1990.

BIO: Larvae on *Guarea trichilioides* L. (Meliaceae), *Cupania* (Sapindaceae) and *Diospyrus* (Ebenaceae) (Todd 1972a). Adults have been reported to damage oranges in northern Mexico by piercing ripening fruits (Todd 1959).

*Melipotis acontoides* (Guenée, 1852)  
(Fig. 72)

ID: Medium to large sized, 3.5–5 cm wing span, light gray species. Hindwings semitranslucent white with a broad gray band along external margin not reaching lower angle; often with a small gray dot just before lower angle.

DIST: Florida, Antilles, south to Brazil, including Galapagos.

GUANA: 4 specimens, 1989.

BIO: Larvae on *Delonix regia* (Bojer ex Hook.) Raf. (royal poinciana) and *Parkinsonia aculeata* L. (Fabaceae) (Martorell 1976, Torres 1994).

COM: Except for *M. acontoides*, species of *Melipotis* are difficult to distinguish because they look very similar to each other and there is a high degree of variation among specimens within each species. Most *Melipotis* species recorded for Guana also occur in southern United States and were reviewed by Richards (1939) and illustrated in color by Bordelon and Knudsen (1999).

The species of this genus are often the most abundant moths at lights in dry areas of the New World tropics. One of the reasons is that they feed on various leguminous plants such as *Acacia*, *Cassia*, *Prosopis*, and other species that are abundant in such habitats. During certain collecting trips, especially immediately after the beginning of rainy season, they came to light in such great numbers that the entire sheet was covered, making it impossible to collect any other moths. On some occasions the lights had to be disconnected and collecting discontinued (VOB pers. obs.).



*Melipotis fasciolaris* (Hübner, [1831])  
(Figs. 73, 74)

ID: Medium to large sized, 3–4.5 cm wing span, variable species—the most variable species of the genus occurring on the island. In some specimens the pattern is less contrasting while in others the contrast is strong. Most specimens can be distinguished from those of other species on the island by the antemedial oblique, pale fascia of forewing. In *M. fasciolaris* the fascia is straight and uniform in width throughout. In some specimens the area basad of the fascia is pale olivaceous. DIST: Southern United States, Antilles, south to Uruguay.

GUANA: 7 specimens, 1989.

BIO: Unknown, however Wolcott (1951) noted “Numerous caterpillars hiding under loose bark of trees of *Guaiacum officinale* L. (Zygophyllaceae), presumably after feeding at night on the foliage”. This observation should be verified because this tree generally grows together with many leguminous species known as food plants of other species of *Melipotis*.

*Melipotis contorta* (Guenée, 1852)  
(Fig. 75)

ID: Same size as larger specimens of *M. acontioides* and *M. fasciolaris*, but not as variable. Very similar to *M. famelica* with which it shares the white basal area of hindwing, and pale head and dorsal area of thorax. Easily separated from *M. famelica* by the irregular pale area at the end of cell. In the latter this is nearly rounded, whereas in *contorta* its lower end extends broadly towards the external margin.

DIST: Florida, Antilles.

GUANA: 4 specimens, 1989, 1990.

BIO: Unknown.

*Melipotis famelica* (Guenée, 1852)  
(Fig. 76)

ID: Very similar to *M. contorta* in size and pattern. Color pattern not highly variable but sexually dimorphic. Females have pattern less contrasting than males. Some males have antemedial fascia tinged reddish brown.

DIST: Southern United States, Antilles, south to Venezuela, including Bermuda (Ferguson et al. 1991).

GUANA: 9 specimens, 1987, 1989, 1990.

BIO: Larvae on *Leucaena latisiliqua* (L.) Gillis & Stearn (Fabaceae) (Martorell 1976).

*Melipotis ochrodes* (Guenée, 1852)  
(Fig. 77, 78)

ID: Easily confused with *M. indomita*, a neotropical species also recorded from the Greater Antilles but

not collected on Guana. Highly variable. Basal area of hindwing semitranslucent gray, not whitish as in *M. contorta* or *M. famelica*, or almost dark gray as in *M. januaris*.

DIST: Antilles, Mexico, south to Brazil.

GUANA: 1 specimen, 1989.

BIO: Larvae on *Prosopis juliflora* (Sw.) DC. and *Schrankia portoricensis* Urb. (Fabaceae) (Martorell 1976).

COM: The specimen illustrated here, identical to the one collected on Guana, matches the series at BMNH identified as *M. ochrodes* (type specimen in MNHN, Paris, not examined). This species could represent only a smaller form of *M. indomita*.

*Melipotis januaris* (Guenée, 1852)  
(Figs. 79, 80)

ID: On average slightly smaller than other *Melipotis* species on the island; sexually dimorphic. Males have forewing with very contrasting, dark brown pattern; females little contrasting, reddish brown. Easily distinguished from all other species on the island by almost entirely dark gray hindwing.

DIST: Southern United States, throughout Antilles, south to the Guianas and Colombia.

GUANA: 1 specimen, 1987.

BIO: Larvae on *Inga laurina* (Sw.) Willd. [as *I. fagifolia*] (Fabaceae) (Martorell 1976).

*Ascalapha odorata* (Linnaeus, 1758)  
(Witch moth, black witch)

ID: Distinguished by very large size and broad wings showing bluish hue. Sexually dimorphic; males blackish gray, females lighter in color, with more contrasting pattern, and with three close, parallel, zig-zag, white lines crossing the wings.

DIST: Originally South American, now Pantropical.

GUANA: 3 specimens, 1982 (J. Lazell), 1988, 1989.

BIO: Larvae on various leguminous trees, including *Acacia*, *Cassia* and *Piptadenia* (Hayward 1969, Hayes 1975). Comstock (1936), Schreiter (1936) and Bourquin (1947) describe its life history and immature stages.

COM: Illustrated in several works, including Covell (1984), Ferguson et al. (1991), Hayes (1975), and Kimball (1965).

*Epidromia lienaris* (Hübner, 1823)  
(Fig. 81)

ID: Large, 5 cm wing span; highly variable, gray fuscous species; forewing with conspicuous reniform black mark at middle and a postmedial, almost straight, pale line.

DIST: New World tropics.



GUANA: 1 specimen, 1990.

BIO: The larvae (reported as *E. pannosa* Guenée) were found on *Psidium longipes* (O. Berg) McVaugh (Myrtaceae), and were fed in the laboratory on *P. guajava* L., *Eugenia axillaris* (Sw.) Willd. (Myrtaceae), *Metopium toxiferum* (L.) Krug & Urb., and *Rhus copallina* L. (Anacardiaceae) (Dickel 1991).

COM: This is a widespread and highly polymorphic species, described more than 10 times (Becker 2001), and is commonly known in the literature as *E. zethophora* Guenée (Hayes 1975) and *E. pannosa* (Solis 1986, Dickel 1991).

*Manbuta pyraliformis* (Walker, 1858)  
(Fig. 86)

ID: Medium sized, gray species. Forewing speckled with small black dots and with an oblique postmedial yellowish fascia; basal area of this fascia light gray, distal area dark gray. Males with pectinate antennae.

DIST: Florida and Antilles.

GUANA: 1 specimen, 1986.

BIO: Unknown.

COM: Poole (1989) listed this species under *Epidromia* Guenée, however, its genitalia and pectinate antennae are similar to those of species currently placed in *Manbuta* Walker (Becker 2001).

*Ephyrodes cacata* Guenée, 1852  
(Figs. 82, 83)

ID: Resembling *M. absumens* in size and coloration (see above). Variable in color, from reddish brown to gray, mottled with black scales. Distinguished by the strongly angled termen of both wings, especially of the hindwing, forming a small tail. Male antennae strongly pectinate, female filiform.

DIST: Southern United States, throughout the Antilles, south to Colombia.

GUANA: 5 specimens, 1989.

BIO: Larvae on *Sesbania grandiflora* (L.) Pers. (Fabaceae) (Brunner et al. 1975).

*Concana mundissima* Walker, [1858]  
(Fig. 84)

ID: Medium sized, silky shining gray species; forewing with fine, broken, transverse lines and a dark dot near middle, closer to dorsum. Hindwing semitranslucent white, edged with gray.

DIST: Florida, throughout the Antilles, south to Brazil.

GUANA: 7 specimens, 1989, 1990.

BIO: Unknown.

*Massala asema* Hampson, 1926  
(Fig. 85)

ID: Medium sized, 3.5 cm wing span, stout bodied, pale brownish species. Wings shaded brown with ill defined, irregular brownish lines, nearly parallel to each other, from costa to dorsum.

DIST: Antilles.

GUANA: 2 specimens, 1989.

BIO: Unknown.

*Lesmone formularis* (Geyer, 1837)  
(Figs. 90, 91)

ID: Medium sized, gray, sexually dimorphic species; males have two wide ill-defined dark gray bands across the wings; in spread specimens the bands are continuous, crossing both forewing and hindwing. Females lack these bands, however, the edge of the postmedial band in the hindwing is replaced by a straight yellow fascia running from apex to tornus.

DIST: Southern United States, throughout the New World tropics, including Galapagos.

GUANA: 3 specimens, 1987, 1989.

BIO: Larvae on *Cassia* and *Mimosa* (Fabaceae).

*Lesmone hinna* (Geyer, 1837)  
(Figs. 87–89)

ID: Same size and similar to *L. formularis*, but distinguished by the conspicuous round, pale dot on the forewing cell.

DIST: Southern United States, throughout the Antilles, south to Brazil.

GUANA: 5 specimens, 1989.

BIO: Unknown.

*Baniana relapsa* (Walker, 1858)  
(Figs. 92, 93)

ID: Small to medium sized, pale ochreous, sexually dimorphic species. Male forewing with conspicuous triangular black patch near base, close to dorsum; postmedial area black, fading gradually towards termen. Females lack the triangular patch and have the distal area lighter gray, resembling *P. immunis*, but readily distinguished by the dark brown anterior edge of thorax.

DIST: Restricted to the Antilles.

GUANA: 18 specimens, 1986, 1987, 1989, 1990.

BIO: Unknown.

*Eulepidotis addens* (Walker, 1858)  
(Fig. 95)

ID: Small, grayish brown; forewing with three straight lines across, the medial and postmedial double, en-



closing a conspicuous ochreous band. Hindwing with diffuse orbicular mark followed by a short tail on the lower part of external margin.

DIST: Antilles.

GUANA: 12 specimens, 1987, 1989, 1990.

BIO: Larvae on *Inga vera* Willd. (Fabaceae) (Martorell, 1976).

*Eulepidotis modestula* (Herrich-Schäffer, 1869)  
(Fig. 94)

ID: Small, white tinged yellow species, with lines crossing the forewing and a short tail on the hindwing similar to those of former species.

DIST: Antilles.

GUANA: 1 specimen, 1989.

BIO: Larvae on *Ceiba pentandra* (L.) Gaertn. (Bombacaceae) (Martorell 1976).

*Toxonprucha diffundens* (Walker, 1858)  
(Fig. 96)

ID: Small sized, 1.8–2.2 cm wing span, gray species. Highly variable; most specimens have pattern as in *Kakopoda progenies* (see below).

DIST: Antilles, south to Brazil.

GUANA: 1 specimen, 1990.

BIO: Unknown, however, other species in the genus have been reared on *Acacia* (Fabaceae) (Crumb 1956).

*Kakopoda progenies* (Guenée, 1852)  
(Fig. 97)

ID: Medium sized, 2.5–3.0 cm wing span; broad winged, dark gray moth. Wings crossed with many fine waving lines alternating black and pale. Very similar to, and easily confused with, *T. diffundens* (see above), but readily separated by size. Smaller specimens of this species are always larger than the largest of the latter. Males are also separated from *T. diffundens* by the pale brush at the tip of abdomen.

DIST: Florida, throughout the Antilles to Brazil.

GUANA: 4 specimens, 1987, 1989.

BIO: Unknown.

COM: We consider *Kakopoda cincta* Smith, 1900, **new synonym**, described from Florida, to represent the same species.

*Parachabora abydas* (Herrich-Schäffer, [1869])  
(Fig. 98)

ID: Small to medium sized, cupreous brown species; hindwing semitranslucent white, bordered with a wide, diffuse gray area, and veins contrastingly gray.

DIST: Mexico, throughout the Antilles, south to Brazil.

GUANA: 3 specimens, 1988, 1989.

BIO: Unknown.

*Cecharismena abarusalis* (Walker, 1859)  
(Fig. 99)

ID: Small brown species with forewing tinged copper and ferrugineous; apex of forewing pointed. Very similar to the following, but easily separated by the oblique straight medial line.

DIST: Florida, throughout Antilles, south to Brazil.

GUANA: 9 specimens, 1987, 1989.

BIO: Unknown, however, *C. nectarea* Möschler has been reared in Puerto Rico on *Caperonia palustris* (L.) A. St.-Hil. (Euphorbiaceae) (Schaus 1940).

*Cecharismena cara* Möschler, 1890  
(Fig. 100)

ID: Same size and easily confused with *C. abarusalis*. Forewing with violet hue. Readily distinguished from the former by the medial oblique line curved in *C. cara* and straight in *C. abarusalis*.

DIST: Antilles.

GUANA: 2 specimens, 1989.

BIO: Unknown (see *C. abarusalis*).

*Glympis eubolialis* (Walker, [1866])  
(Fig. 101)

ID: Small gray species with forewing crossed, in the middle, with ill defined, straight dark brown band; area distad to this band usually darker than basal area. Shape, size, and color similar to *Bleptina* species (below). Easily distinguished from *Bleptina* by the porrect labial palpi, which are long and upturned in *Bleptina* (see below).

DIST: Antilles.

GUANA: 22 specimens, 1989, 1990.

BIO: Unknown, however, the larvae of *G. concors* were found feeding on *Sesbania grandiflora* (L.) Pers. (Fabaceae) in Puerto Rico (Martorell 1976).

Herminiinae

*Drepanopalpia lunifera* (Butler, 1878),  
**new combination**  
(Figs. 102, 103)

ID: Small to medium sized, 1.5–2 cm wing span, dimorphic, dark fuscous species. Males have very long labial palpi thickly covered with long scales, reflexed over the head to the posterior margin of thorax. Females have long, porrect palpi. Male forewing with a reniform, pale mark at end of cell; in females this mark is reduced to small dot.

DIST: Antilles.



GUANA: 9 specimens, 1987, 1989.

BIO: Unknown.

COM: The series in VOB, including specimens from Guana Island, Tortola, Puerto Rico and Cuba, was compared with material in BMNH. Males match the type of *Drepanopalpia polycyma* Hampson 1898, **new synonym**, and females match the type of *Hypena lunifera* Butler 1878. *D. polycyma* is also curated in BMNH as a synonym of *Mastigophorus latipennis* Herrich-Schäffer. There is no specimen of *M. latipennis* in Coll. Gundlach (IES, Havana) where the type material of the Cuban species described by Herrich-Schäffer is supposed to be deposited. It is possible that some material is in MNHU, Berlin. It is possible that both *M. lunifera* and *M. polycyma* are junior synonyms of *M. latipennis*.

*Lascoria orneodalis* (Guenée, 1854)  
(Figs. 104, 105)

ID: Small to medium sized, 1.5–2 cm wing span, dark fuscous species, resembling *D. lunifera*. Males have labial palpi as in the former species, but the forewing has a strong indentation at middle of external margin. Females have long upcurved palpi as in *Bleptina*.

DIST: Florida, Antilles.

GUANA: 3 specimens, 1987.

BIO: Larvae on tomato leaves (Solanaceae) (Martorell 1976).

*Bleptina hydrillalis* Guenée, 1854  
(Fig. 108)

ID: Dark brown, 1.8–2.0 cm wing span; forewing crossed by three, well defined, pale lines: a straight line near base, and two sinuate lines, one after the reniform mark on cell, the other before external margin. Reniform mark usually pale, but black in some specimens.

DIST: Southern United States, Central America, Antilles.

GUANA: 34 specimens, 1986, 1989.

BIO: Unknown.

*Bleptina caradrinalis* Guenée, 1854  
(Figs. 106, 107)

ID: About same size as *B. hydrillalis*, pale, variable. In those specimens with a dark band across forewing, the band is closer to the middle.

DIST: Southern United States, throughout the Antilles, South to Brazil.

GUANA: 6 specimens, 1989.

BIO: Larvae reported on dead leaves (Kimball 1965).

*Bleptina menalcasalis* Walker, [1859]  
(Figs. 109, 110)

ID: Medium sized, 2.2–2.7 cm wing span, pale species. Forewing diffusely crossed with ill defined, irregular

lines. Distinguished from other noctuids of same size by the long, upcurved labial palpi.

DIST: Antilles, south to Venezuela.

GUANA: 27 specimens, 1986, 1987, 1989, 1990.

BIO: Unknown, but likely dead leaves (see *B. caradrinalis*).

*Bleptina araealis* (Hampson, 1901)  
(Figs. 167, 168)

ID: Very small, 1–1.3 cm wing span, variable, fuscous to dark fuscous species. Forewing often with a dark gray fascia on basal fourth; area basad to fascia paler than rest of wing. Easily distinguished from other small species on the island by the very long upcurved labial palpi and by three very small, round, pale dots on forewing, the first just outside the basal band and the two others close together at end of cell.

DIST: Antilles and Florida (Dickel 1991). The first author recently collected one male and one female in Mexico: Tamaulipas, El Encino.

GUANA: 12 specimens, 1987, 1990.

BIO: Unknown (see previous species).

Hypeninae

*Hypena lividalis* (Hübner, 1790)  
(Fig. 111)

ID: Small, gray; forewing with straight, white post-medial line; area basad of line olive, area distad gray.

DIST: South Palearctic, Pantropical.

GUANA: 2 specimens, 1989, 1990.

BIO: Larvae on *Urtica* and *Parietaria* spp. (Lödl 1994:502).

COM: In a revision of the genus, Lödl (1994) listed six synonyms under *H. lividalis*, two of them originally described from material collected in the Antilles.

*Hypena minualis* (Guenée, 1854)  
(Fig. 166)

ID: Small, dark gray species with little contrasting markings. Forewing with a slightly paler basal area, separated from the external dark area by an ill defined oblique, dark gray line from near base of costa to middle of dorsum; a faint dash near apex. The palpi resemble those of female *D. polycyma*, but readily separated from the latter by the absence of the pale dot on cell.

DIST: Antilles, south to Brazil.

GUANA: 3 specimens, 1989.

BIO: Larvae on *Sida rhombifolia* L. (Malvaceae) (Ferguson et al. 1991).



## ARCTIIDAE

## Arctiinae

*Hypercompe simplex* (Walker, 1855)  
(Figs. 112, 114)

ID: Large, white; forewing with outer half translucent, basal half with a series of annulate black edged spots. Abdomen orange with subdorsal pairs of dark bluish dots. Females much larger than males; spots on the abdomen white.

DIST: Puerto Rico, Virgin Islands and Lesser Antilles.  
GUANA: 6 specimens, 1987, 1989.

BIO: Martorell (1976) lists over a dozen hostplants, including *Cedrela* (Meliaceae), *Cissus* (Vitaceae), *Erechtotes* (Compositae), *Erythrina* (Fabaceae), *Ipomaea* (Convolvulaceae), tomato, banana, beans, guava, eggplant and *Solanum torvum* Sw. (Solanaceae).

COM: Commonly found in the literature, including in Martorell (1976), as *Ecpantheria icasia* (Cramer), a similar species from continental South America.

*Calidota strigosa* (Walker, 1855)  
(Fig. 115)

ID: Large, gray moth with pink abdomen. Forewing with veins darker than ground color, shortly interrupted with pale. Cannot be confused with any other moth from the island.

DIST: Antilles and Southern United States.

GUANA: 28 specimens, 1984, 1987, 1989, 1990.

BIO: Dyar (1901:270) reared this species on *Guetarda elliptica* Sw. (Rubiaceae) and described its larvae; Martorell (1976) lists the same plant as its host in Puerto Rico.

COM: Franclemont (1983) and Watson & Goodger (1986) resurrected, respectively, *C. laqueata* (Edwards 1887) (type-locality: USA) and *C. cubensis* (Grote [1866]) (type-locality: Cuba) from the synonymy of *strigosa*. We believe they are only geographical forms of the same species.

In the resting position, the adult looks cryptic but when touched it opens the wings exposing the bright pink abdomen that seems to be aposematic. A specimen was picked from the collecting sheet by a pearly-eyed thrasher, *Margarops fuscatus* (Vieillot), and rejected. The same specimen was placed back on the wall where the bird often perched. The same bird picked up the moth again and then dropped it again (VOB pers. obs.).

*Eupseudosoma involutum* (Sepp, [1855])  
(Fig. 116)

ID: Medium sized, white moth, with red abdomen. Cannot be confused with any other species in the island.

DIST: Southern United States, throughout Antilles, south to Argentina.

GUANA: 4 specimens, 1987.

BIO: Larvae on guava (*Psidium guineense* Sw.), *Eugenia*, *Eucalyptus*, and other Myrtaceae.

*Utetheisa ornatrix* (Linnaeus, 1758)  
(Fig. 117)

ID: Medium sized, variable white moth. Most specimens have the forewing white, tinged pink, and a pink costa interrupted regularly by dark gray dots. In other specimens most of the white is replaced by pink and the wing is crossed with transverse rows of dark gray dots. The proportion of gray in the hindwing also varies; in some specimens it is restricted to the borders, while in others it covers most of the area.

DIST: Southern United States, throughout the Antilles, south to Argentina.

GUANA: 5 specimens, 1984, 1988, 1989, 1990.

BIO: Larvae on various species of *Crotalaria* (Fabaceae).

COM: Commonly found flying during the day in open, disturbed areas where its host plants often grow. Pease (1973) discussed the variation of this moth in the Virgin Islands.

*Utetheisa pulchella* (Linnaeus, 1758)  
(Fig. 118)

ID: Easily confused with the dotted form of *U. ornatrix* (see above); easily separated by the dots on dorsum of thorax. *Utetheisa ornatrix* has three pairs; *U. pulchella* has only three dots.

DIST: Africa and Asia, now established in the New World tropics, but very rare in collections. The first author collected two specimens in Brazil, one at Pipa Beach, south of Natal, Rio Grande do Norte, and one in Planaltina, DF, near Brasília, which is the southern most record for the species in the New World.

GUANA: 1 specimen, 1990.

BIO: Larvae on *Myosotis* (Boraginaceae) and grasses (Hampson 1901).

## Pericopinae

*Composia credula* (Fabricius, 1775)  
(Fig. 113)

ID: Large, black, with body and wings dotted white; forewing with deep red markings on basal half below costa.

DIST: Endemic to the Antilles, this is the only species of the genus found on the Puerto Rican Bank.

GUANA: 10 specimens, 1984, 1986, 1987, 1989.

BIO: Unknown. Its closest relative, *C. fidelissima*



Herrich-Schäffer, from Cuba and Florida, has been reared on *Canavalia* (Fabaceae), oleander (*Nerium*), and *Echites* (Apocynaceae) (Kimball 1965).

COM: Commonly referred to in the literature by its junior synonym *C. sybaris* (Cramer). It is a crepuscular moth, commonly found flying along the trails before dark. Todd (1982) states it "occurs throughout the Greater Antilles, and south to Brazil" but that the "continental distribution needs to be studied." Previous authors (Forbes 1930, Bates 1933) considered it to be endemic to the Antilles. In the series in USNM there is only one non-Antillean specimen, an old specimen labeled only "Brazil," which we believe to be mislabeled. We are not aware of any other continental records for this large and colorful species, which would not be overlooked by collectors.

#### Ctenuchinae

*Empyreuma pugione* (Linnaeus, 1767)  
(Fig. 119)

ID: Large, wasp-like moth with conspicuous red wings and black body. Wings bordered dark gray, and body tinged iridescent green.

DIST: Apparently restricted to the Puerto Rican Bank.

GUANA: 9 specimens, 1984, 1987, 1989, 1990.

BIO: Larvae on oleander, *Nerium oleander* L. (Apocynaceae) (Gundlach 1881).

COM: Day flying; very likely a Müllerian mimic of *Pepsis rubra* (Drury) (Hymenoptera: Pompilidae) (R. Snelling det.), as its larvae feed on a toxic plant. Similar to other arctiids, the larvae presumably sequester alkaloids from the host plant. Referred to in the older literature as *E. lichas* (Cramer).

*Horama pretus* (Cramer, 1777)  
(Fig. 121)

ID: Large, wasp-like, ochreous brown species, distinguished by the broad white band across base of abdomen.

DIST: Antilles.

GUANA: 36 specimens, 1984, 1985, 1987, 1989, 1990.

BIO: Larvae on *Cassine xylocarpa* Vent. [as *Elaeodendron xylocarpum*] (Celastraceae) (Wolcott 1951).

COM: Day flying, commonly seen visiting flowers. Presumably a Müllerian mimic of *Polistes major* Palisot de Beavois (Hymenoptera: Vespidae) (R. Snelling det.).

*Horama panthalon* (Fabricius, 1793)  
(Fig. 120)

ID: Similar but smaller than *H. pretus*. Distinguished by pattern on abdomen: only a small white dash across base, followed by alternating ochreous and black bands.

DIST: Southern United States, throughout the Antilles, south to southern Brazil.

GUANA: 13 specimens, 1986, 1989, 1990.

BIO: Unknown.

COM: Dietz and Duckworth (1976) divided the species into three subspecies, assigning the Antillean population to the nominal form. Very likely a Müllerian mimic of *Polistes crinitus* (Felton) (Hymenoptera: Vespidae) (R. Snelling det.).

*Cosmosoma achemon* (Fabricius, 1781)  
(Fig. 122)

ID: Small, wasp-like moth with unique combination of colors. Mostly orange with vertex of head and subdorsal sides of abdomen metallic bluish green; forewing with translucent areas.

DIST: Antilles south to Brazil.

GUANA: 10 specimens, 1989, 1990.

BIO: Unknown.

*Eunomia colombina* (Fabricius, 1793)  
(Fig. 123)

ID: Medium sized, wasp-like moth with black body and translucent wings. Forewing bordered black with a dark, red mark at end of cell connected with costa. Thorax striped white; abdomen with a carmine red band across the base, expanding laterally, followed by a white band, partially interrupted dorsally; the rest banded with alternating, narrow, red and white lines.

DIST: Antilles. Hampson (1898) gives also Honduras and Brazil, but the material studied by him should be checked.

GUANA: 1 specimen, 1989.

BIO: "Oruga en las convolvulaceas" (Gundlach 1881).

COM: Listed as *E. columbina*, a misspelling, by Wolcott (1951).

*Nyridela chalciope* (Hübner, [1831])  
(Fig. 124)

ID: Medium sized, wasp-like, black moth with transparent wings. Head, thorax dorsally, base of wings, legs, and abdomen dorsally and laterally with iridescent blue. Antennae yellow. Forewing bordered black with an oblique transverse band from middle of costa to tornus.

DIST: Described from Havana, occurs throughout the West Indies and Central America, south to Panama.

GUANA: 1 specimen, 1990.

BIO: Larvae on *Cupania americana* L. (Sapindaceae) (Möschler 1890).

COM: Some authors regard the Central American



population as belonging to a separate species, *N. xanthocera* (Walker).

#### Lithosiinae

*Afrida charientisma* Dyar, 1913  
(Fig. 169)

ID: Very small, 8–12 mm wing span, slightly variable species. Forewing mostly grayish, slightly tinged with green, crossed by alternating, ill defined whitish and dark gray bands. Easily recognized by the antemedial whitish band across forewing, starting from costa and running obliquely outwards to middle, then bent to base towards dorsum.

DIST: Antilles.

GUANA: 27 specimens, 1985, 1986, 1990.

BIO: Unknown, however, most of the species of this subfamily are lichen-feeders (Hampson 1900).

*Progonia pallida* (Möschler, 1890)  
(Fig. 170)

ID: Small, pale species, with no markings. Forewing slightly dusted gray.

DIST: Previously known only from Puerto Rico.

GUANA: 6 specimens, 1986, 1990.

BIO: Unknown.

*Lomuna nigripuncta* (Hampson, 1900)  
(Fig. 171)

ID: Small, 1.3–1.7 cm wing span, whitish moth. Forewing dusted gray, conspicuously spotted with small, dark gray dots.

DIST: Previously known only from Puerto Rico (Field 1952).

GUANA: 29 specimens, 1984, 1985, 1986, 1990, 1991.

BIO: Unknown.

#### GEOMETRIDAE

##### Oenochrominae

*Almodes terraria* Guenée, [1858]  
(Fig. 134)

ID: Medium sized, gray species. Wings densely dusted with dark gray scales and crossed with pale and dark ill defined, irregular bands. Males easily recognized by the strongly pectinate antennae nearly the length of forewing. Females have a slight olivaceous tinge, and external margins of both wings more strongly dentate.

DIST: Southern United States, throughout the Antilles to Colombia.

GUANA: 2 specimens, 1990.

BIO: Unknown.

##### Ennominae

*Pero rectisectaria* (Herrich-Schäffer, [1855])  
(Figs. 125, 126)

ID: Medium sized, sexually dimorphic, variable species. Males with ground color varying from pale to dark brown; forewing with antemedial band, when visible, strongly bent to the base near costa, post-medial band nearly straight, with area distad to it much paler than rest of wing. Females more reddish brown. Easily distinguished from other species of same size by the conspicuously scalloped forewing margin near apex.

DIST: Puerto Rico, throughout the Lesser Antilles.

GUANA: 42 specimens, 1986, 1987, 1988, 1989, 1990.

BIO: Unknown.

COM: Poole (1987), who revised this large genus, stated that "Either it is rare, or it occurs in areas not commonly collected." Judging from the long series collected by us, it is not rare. It was common in October 1989, just after hurricane Hugo, when the first author had dozens of specimens on the light and selected 10 males and 4 females.

*Oxydia vesulia* (Cramer, [1779])  
(Fig. 127)

ID: Large, extremely variable species, with no two identical specimens. Ground color of both wings varying from pale yellow, through pale gray to brown, clouded and irrorated in various degrees by gray. Forewing with an oblique post medial band from apex to near middle of dorsum. Easily recognized by the white vertex of head.

DIST: Southern United States, Antilles, south to Argentina.

GUANA: 4 specimens, 1987.

BIO: Larvae on *Acalypha* (Euphorbiaceae), *Cinchona* (Rubiaceae), *Cissampelos* (Menispermaceae), *Citrus* (Rutaceae), *Persea* (Lauraceae), *Rosa* (Rosaceae), and *Securidaca* (Polygalaceae) (Martorell 1976, Torres 1992).

*Erastria decrepitaria* (Hübner, [1823])  
(Figs. 128, 129)

ID: Medium sized, yellow moth. Sexually dimorphic: males suffused olive, especially forming a wide bar along external margin; females more yellowish with the external olive area reduced to a faint irregular band, with a conspicuous dark spot on the band near the tornus.

DIST: Southern United States, throughout Antilles, south to Brazil.

GUANA: 4 specimens, 1987, 1989.

BIO: Unknown.



*Sphacelodes fusilineatus* (Walker, 1860),  
**revised status**  
 (Figs. 130, 131)

ID: Medium sized, dimorphic species. Males dark olive brown; forewing crossed with three equidistant, nearly parallel lines and with a subtriangular gray mark on costa between medial and postmedial line. Females brown with lines same as males, but mark on costa absent.

DIST: Antilles.

GUANA: 25 specimens, 1986, 1988, 1989, 1990.

BIO: Unknown.

COM: This species has been confused in the literature with *S. vulnerarius* (Hübner). The two differ in many features, the most obvious the color of antenna and costal mark of forewing. In *S. fusilineatus* the antenna and costal mark are light gray, whereas in *vulnerarius* the antenna is ochreous and the costal mark reddish brown. *Sphacelodes fusilineatus* was described from material with no locality label. There is a series in VOB collected in Guana, Tortola, St. Thomas, and Cuba. One of these was compared with and matches the type of *S. fusilineatus*. It is very likely that this is the species referred to by Kimball (1965:192) as "5221, 1 S. SP.", and listed by Ferguson (1983:95) as *S. haitiaria* Oberthür. The series of *S. vulnerarius* in VOB was collected in Cuba, Mexico, and Brazil. In Cuba, *S. fusilineatus* was captured at Pinares de Mayari, Holguín, while those of *vulnerarius* at Viñales, Pinar del Río. The first locality is dry, similar to the conditions in St. Thomas and Guana, while the second is humid, similar to those areas on the American continent from where the series of *S. vulnerarius* came.

*Macaria paleolata* (Guenée, [1858])  
 (Fig. 132)

ID: Small, slightly variable, pale species. Wings crossed by two ill defined, nearly straight bands; area distad to postmedial band darker than rest of the wing. Distinguished by head and anterior margin of thorax ochreous.

DIST: Antilles.

GUANA: 24 specimens, 1989, 1990.

BIO: Unknown, however, other species of this large genus feed on leguminous species (Fabaceae).

COM: This species was transferred from *Semiothisa* to *Macaria* by Scoble (1999). It is very likely that other, similar species of the large genus *Macaria* occur on the island.

*Patalene ephyrata* (Guenée, [1858])  
 (Fig. 133)

ID: Small, variable, pale yellow to pale brown species. Forewing with antemedial band nearly evenly

rounded, postmedial band straight to near apex then strongly angled basad to costa. Hindwing with a single, straight band near middle. Distinguished by pointed apex and the sinuate external margin of forewing.

DIST: Antilles (Herbulot 1984).

GUANA: 41 specimens, 1986, 1987, 1988, 1989, 1990.

BIO: Larvae on *Ficus* (Moraceae) and *Ricinus* (Euphorbiaceae) (Brunner et al. 1975).

*Cyclomia mopsaria* Guenée, [1858]  
 (Figs. 182, 183)

ID: Small, extremely variable species. Ground color often pale tinged reddish brown, to dark reddish brown. Forewing varying from unmarked to marked with transverse, ill defined, irregular lines. Hindwing pale to orange, often bordered with reddish brown. Similar to small noctuids such as *Eublemma* spp., but distinguished by the bipectinate antenna in males. Distinguished from other small geometrids by sharply pointed, porrect labial palpi, unusually long for a geometrid.

DIST: Antilles, south to Brazil.

GUANA: 11 specimens, 1987, 1989, 1990.

BIO: Unknown, however, *Erythroxylum havanense* Jacq. (Erythroxylaceae) has been listed as food plant of "*Cyllomia* sp. [presumably a misspelling] Un gusano medidor," in Cuba (Brunner et al. 1975).

COM: Its extreme variation led to its description several times. It is likely that after revision more names will be added to the six junior synonyms currently listed (Becker in prep.).

Geometrinae

*Eucana simplaria* Herbulot, 1986  
 (Figs. 12–14, 141, 142)

ID: Small to medium sized, bluish green species. Lines on wings almost indistinct. Vertex of head white; abdomen with traces of a whitish line dorsally. Genitalia (Figs. 12–14) very similar to those of *E. niveociliaria* (Herrich-Schäffer), illustrated in Ferguson (1985: fig. 25a–e).

DIST: Guadeloupe.

GUANA: 17 specimens, 1986, 1989.

BIO: Unknown, but Scoble (1999) records *E. niveociliaria* from Rhamnaceae.

COM: Of all "greens" from the island this is the only bluish species, and it is slightly larger than the other species. The subfamily was revised for North America by Ferguson (1985) and for the neotropics by Pitkin (1996).

*Phrudocentra centrifugarium* (Herrich Schäffer, 1870)  
 (Figs. 143–146)

ID: Medium sized, extremely variable, bright green species. Some specimens, usually males, have only



small, dark brown dots on wings, one on cell and the others along what would be the antemedial and post-medial lines; others have larger marks, of various sizes and shapes, whitish or brownish, above tornus. Abdomen has a series of minute, white dots dorsally, one on each segment.

DIST: Florida, throughout Greater Antilles to Puerto Rico (Ferguson 1985).

GUANA: 4 specimens, 1990.

BIO: Larvae on *Myrica cerifera* L. (Myricaceae) (Scoble 1999).

*Chloropteryx paularia* (Möschler, 1886)  
(Fig. 186)

ID: Small, olivaceous species. Wings with antemedial and postmedial rows of minute whitish dots forming irregular lines. This is the only species of the green Geometrinae with this color.

DIST: Florida, throughout the Antilles.

GUANA: 11 specimens, 1987, 1989, 1990.

BIO: Larvae on *Myrica cerifera* L. (Myricaceae) in Florida (Ferguson 1985).

*Synchlora frondaria* (Guenée, [1858])  
(Fig. 187)

ID: Small, bright green species. Distinguished from *S. cupedinaria* by the concolorous fringes.

DIST: United States, throughout the Antilles, south to Argentina.

GUANA: 29 specimens, 1986, 1988, 1989, 1990.

BIO: Larvae on *Stilingia* (Euphorbiaceae), *Pluchea*, *Bidens*, *Chrysanthemum*, *Helianthus* (Asteraceae), *Rubus* (Rosaceae), *Glycine max* (L.) Merr., and *Prosopis* (Fabaceae) (Ferguson 1985).

*Synchlora cupedinaria* (Grote, 1880)  
(Fig. 188)

ID: Small, bright green species. Wings thickly bordered with brown. Thorax and abdomen brown dorsally; abdomen usually with white dots dorsally. Easily distinguished from the other green Geometrinae by the brown thorax and abdomen.

DIST: Florida, throughout Greater Antilles to Virgin Islands, to Nevis (Herbulot 1984).

GUANA: 41 specimens, 1985, 1986, 1988, 1989, 1990.

BIO: Larvae on *Lantana camara* L. (Verbenaceae) (Scoble 1999).

### Sterrhinae

Of all the moths treated in this paper, the Sterrhinae have proven to be most difficult to identify. We have tried to reflect the species concepts as represented in the BMNH and USNM collections, and have followed the

generic placements in Scoble (1999). Our dissections of types, as well as Guana specimens, indicate that many problems exist in the existing classification, and full resolution of the names is beyond the scope of this paper.

*Semaepus malefidarius* (Möschler, 1890)  
(Fig. 135)

ID: Medium sized, pale moth densely irrorated with reddish brown scales. Wings crossed with ill defined, hardly contrasting, irregular bands, slightly darker than ground color.

DIST: Puerto Rico, Virgin Islands.

GUANA: 14 specimens, 1989, 1990.

BIO: Unknown.

COM: Closely related to *S. castarium* (Guenée) from the Greater Antilles.

*Leptostales noctuata* (Guenée, [1858])  
(Figs. 136, 137)

ID: Small to medium sized, pale species, densely irrorated with olive scales. Forewing with antemedial and postmedial bands darker than ground color, termen sinuate, apex pointed. Males show a dark mark on cell; in females this mark is reduced and faint.

DIST: Antilles.

GUANA: 19 specimens, 1986, 1987, 1988, 1989, 1990.

BIO: Unknown.

*Acratodes suavata* (Hulst, 1900)  
(Fig. 185)

ID: Small, white species; wings crossed with three ill defined, little contrasting, grayish bands; medial and postmedial closer together. The only white geometrid on the island with no contrasting marks on wings.

DIST: Southern United States, Antilles.

GUANA: 31 specimens, 1985, 1986, 1987, 1988, 1989, 1990.

BIO: Larvae on *Randia aculeata* L. (Rubiaceae) (Kimball 1965).

COM: It is very likely that *A. virgotus* (Schaus), described from Jamaica, is a synonym. Our series matches the type of *A. virgotus* in USNM.

*Lobocleta nymphidiata* (Guenée, [1858])

ID: Small, white species with wings crossed with 4–5 narrow, irregular dark brown lines, consisting of rows of dark dots.

DIST: Antilles.

GUANA: 1 specimen, 1985.

BIO: Unknown.



*Scopula laresaria* Schaus, 1940  
(Fig. 178)

ID: Small, pale whitish, irrorated with scattered gray scales; forewing crossed with poorly defined, irregular, narrow pale yellowish lines. Same size and color as *L. nymphidiata*, but readily distinguished by the blackish vertex of head, white in *L. nymphidiata*.

DIST: Puerto Rican bank.

GUANA: 9 specimens, 1985, 1988, 1989.

BIO: Unknown.

*Idaea* sp., probably *I. fernaria* (Schaus, 1940),  
**new combination**  
(Figs. 179, 180)

ID: Small, light gray, densely irrorated with dark gray scales; wings crossed with three, ill defined, irregular, narrow, dark gray lines more or less interrupted, giving the impression that they are densely dotted; both wings with black dot on cell. Females slightly lighter than males.

DIST: Antilles.

GUANA: 27 specimens, 1985, 1986, 1988, 1987, 1989.

BIO: Unknown.

COM: Based on the structure of male genitalia and eighth sternite of a male paratype, this species does not belong in *Scopula*, so we are provisionally transferring it to *Idaea fernaria*, **new combination**, following the generic concept of Holloway (1997). The Guana specimens are very similar to the type series of *Idaea fernaria*, but differ in the size of the long expansion on the juxta. In Guana specimens it is much longer than in a paratype of *I. fernaria*, nearly the size of the valvae, expanding beyond the uncus. *Idaea fernaria* is externally similar to *I. amnesta* (Prout, 1922), from Jamaica, but the male genitalia are very different.

"*Idaea*" *monata* (Forbes in Ramos, [1947])  
(Figs. 172, 173)

ID: Very small, gray species; antemedial and postmedial lines dark gray, strongly contrasting, especially in the males; in some males the area between the two lines are dusted dark gray, forming a wide band across the wings.

DIST: Antilles.

GUANA: 29 specimens, 1985, 1986, 1989, 1988, 1990.

BIO: Unknown.

COM: This species is very similar to *Idaea insulensis* (Rindge, 1958), from Florida, but differs in the base of the valvae being more expanded in *I. insulensis* than in *I. monata*, although study of extensive series could show this to be interspecific variation. Based on the

structure of the male genitalia (Rindge 1958:fig. 9), neither *I. monata* or *I. insulensis* are properly placed in *Idaea* (cf. Holloway 1997), but recognition of the proper generic placement is beyond the scope of this paper. Weakly patterned individuals of *I. monata* are similar externally to *Lobocleata nataria* (Walker, 1866), but the male genitalia do not match the type of *L. nataria* in BMNH.

*Idaea minuta* (Schaus, 1901)  
(Figs. 176, 177)

ID: Very small, 8–10 mm wing span, pale species. Wings crossed with several, narrow, ill defined, irregular, light brown lines. One of the smallest geometrid species on the island.

DIST: Antilles, USA.

GUANA: 19 specimens, 1985, 1987, 1988, 1989.

BIO: Unknown.

COM: Specimens belonging to this series were identified as *I. minuta* by C. Covell, and also matched the type of *Ptychopoda curtaria* Warren 1904, **new synonym**, from Jamaica, in BMNH.

*Idaea eupitheciata* (Guenée, [1858])  
(Figs. 174, 175)

ID: Very small, sexually dimorphic, pale species, with wings crossed with irregular reddish brown bands. Males paler than females; forewing with small tuft of dark scales near dorsum; hindwing with a small tail near tornus. Females darker than males and without the tufts and tails.

DIST: Antilles.

GUANA: 16 specimens, 1985, 1988, 1989, 1990.

BIO: Unknown.

*Leptostales phorcaria* (Guenée, [1858])  
(Fig. 181)

ID: Small, reddish brown; wings crossed with narrow, ill defined, irregular, yellowish lines; thorax dorsally and forewing costa yellow. Cannot be confused with any other species on the island.

DIST: Antilles.

GUANA: 2 specimens, 1989.

BIO: Unknown.

*Leptostales oblinataria* Möschler, 1890  
(Fig. 184)

ID: Small, olivaceous species, with a broad reddish brown band across the forewing, delimited by medial and postmedial bands. Some specimens with this band faded. Cannot be confused with any other species on the island.



DIST: Southern United States, Antilles, into South America (Covell 1969).

GUANA: 15 specimens, 1988, 1989, 1990.

BIO: Unknown.

#### Larentiinae

*Obila praecurraria* (Möschler, 1890)

(Fig. 138)

ID: Large species with velvet moss green forewing and orange ochreous hindwing. Forewing crossed with numerous alternating pale and dark gray waving bands. Hindwing with a wide gray band extending inwards, along internal margin, to the base. Female with middle of forewing crossed with a wide, irregular whitish band.

DIST: Antilles.

GUANA: 1 specimen, 1989.

BIO: Unknown.

COM: Our specimen matches the type of *Pterocypha xantholiva* Warren, 1895, synonymized with this by Schaus (1940:326).

*Pterocypha defensata* Walker, 1862, **revised status**

(Figs. 139, 140)

ID: Medium sized, variable, moss gray. Similar to *O. praecurraria*, but slightly smaller and lacking the orange ochreous hindwing color.

DIST: Southern United States, Antilles.

GUANA: 20 specimens, 1986, 1987, 1989, 1990.

BIO: Unknown.

COM: Commonly referred to in the literature, including Scoble (1999), by its synonym *P. floridata* (Walker), but *P. defensata* was described in 1862 and *P. floridata* in 1863, so *defensata* has priority.

#### HYBLAEIDAE

*Hyblaea puera* (Cramer, 1777)

(Fig. 150)

ID: Medium sized, fuscous species with hindwing beautifully decorated with yellow to orange patches. Abdomen dorsally crossed with narrow lines behind each segment.

DIST: Pantropical.

GUANA: 2 specimens, 1989, 1990.

BIO: Larvae on *Crescentia cujete* L., *Spatodea campanulata* P. Beauv., *Tabebuia heterophylla* (DC.) Britton (Bignoniaceae), and *Petitia domingensis* Jacq. (Verbenaceae) (Martorell 1976). Considered as a minor pest of forest trees in Puerto Rico (Torres 1994). Immature stages described by Singh (1995).

COM: Taxonomy of the related species discussed by Berio (1967), but *H. puera* apparently represents a species complex (Shaffer & Nielsen 1996).

#### COSSIDAE

*Psychonoctua personalis* Grote, 1865

(Figs. 147–149)

ID: Medium to large, 2–4.5 cm wing span, narrow winged, gray species. The short, strongly pectinate antennae, and abdomen thickly clothed with long scales makes it easily recognized from any other large moths on the island.

DIST: Antilles and Mexico.

GUANA: 5 specimens, 1990.

BIO: The larvae are wood borers in many trees, sometimes causing severe damage to orange, coffee, white mangle, sea grape, etc. (Wolcott 1951).

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## APPENDIX

*Catabenoides* Poole, new genus

[The following new generic description was intended to appear in a fascicle of the series *Moths of America North of Mexico*. Because this fascicle will not be published in the foreseeable future, the author has permitted us include the new generic name here, in order to allow us to describe *Catabenoides lazelli* in the proper place.]

Type-species: *Adipsophanes terminellus* Grote, 1883

*Catabenoides* contains the majority of the species previously placed in *Catabena*. The genus appears to be an outlier of a large group in southern South America, primarily Paraguay and Argentina. The genus is postulated to be closest phylogenetically to *Catabena* and *Neogalea*, but it has a number of curious synapomorphies making its affinities somewhat problematical. The principle identifying characters are in the male and female genitalia. In the male valve the bottom margin of the sacculus in both the right and left valves is produced into a long process separate from the clasper. The ventral margins of the valvae have strong elongate setae. The sacculus is lightly chitinized proximal to the clasper separating off a much more heavily sclerotized plate.

In addition to the three species known from North America (the type species, *C. vitrina* (Walker), **new combination**, and *C. divisa* (Herrich-Schäffer), **new combination**), there is one previously described species; *Catabenoides seorsa* (Todd) (*Catabena seorsa* Todd), **new combination**, from the Galapagos Islands. There are two undescribed species in the West Indies [one of these is described herein as *C. lazelli*], one undescribed species from central Mexico, and at least two unnamed species from Paraguay. The exact affinities of *Catabenoides*, *Catabena*, and *Neogalea* with the Argentina and Chilean faunas remain to be determined. The single remaining described species in "Catabena" of Poole (1989), *Laphygma terens* Walker, was described from "Venezuela." The type is rubbed and its abdomen is missing. I have not been able to match it with any specimens from the extensive Venezuela material in the USNM. It appears superficially to be a *Catabenoides*. Therefore for book-keeping purposes, I place it as *Catabenoides terens* (Walker), **new combination**.

**Description. Head:** Lashes absent; eyes large, naked; frons slightly swollen, very closely scaled; antenna simple, faintly ciliate; palpi unremarkable for the tribe; proboscis normal; two thin ridges of flattened scales between the bases of the antennae. **Thorax:** Patagia capable of being raised in a hood; vestiture of dorsum of thorax of flattened scales without hairs; slight metathoracic tuft; vestiture of wings of flattened scales; no sign of sexually modified scales in male. **Prothoracic leg:** Tibia with later ridge of hair giving it a flattened look; no tibial claw; tibia approximately as long as first three tarsal segments; first four tarsal segments with three rows of spines; tarsal claw without a tooth. **Mesothoracic and metathoracic legs:** Proximal third of tibia with tuft of long hairs and scales; tibia approximately as long as first three tarsal segments. **External tympanic region:** Approximately as in *Supralathosea* Barnes & Benjamin, however, first tergum much shorter than in *Catabena* and *Supralathosea* and with a strong definite proximal lip as in *Apharetra* Grote; hood strong. **Internal tympanic region:** Not examined. **Abdomen:** Very weak tuft on first tergite; male with basal hair pencils and accessory hair pencils in known species. Eighth sternum with strong row of hairs in middle of U-shaped pleurite. **Male genitalia** (Figs. 2, 3): Valvae characterized by production of ventral margin of sacculus into a process of various shapes; ventral margin of valvae with strong modified setae; a weak unsclerotized area before origin of clasper; uncus swollen with an apical tooth; juxta a single pointed plate; vesica in type species elongate-ovate, connected by a short neck to body of aedeagus; type species with a group of elongate, fused spines at apex of vesica and with groups of short, stubby spines near the middle and ventral margin of the vesica; vesica variable in other species. **Female genitalia:** Ovipositor lobes square, unmodified; ductus bursa well sclerotized, elongate, mushroom shaped in type species, separated by a distinct junction from the heavily sclerotized upper part of bursa; bursa bilobed, but lobes not distinctly separate; corpus bursae with stellate ridges, but no signum. **Larva and foodplants:** Unknown for North American species but recorded as *Lantana peduncularis* Andersson (Verbenaceae) in *Catabenoides seorsa* from the Galapagos.

Robert W. Poole

Nearctica  
Rockville, Maryland



## BOOK REVIEWS

*Journal of the Lepidopterists' Society*  
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**THE FAMILIES OF MALESIAN MOTHS AND BUTTERFLIES**, by J. D. Holloway, G. Kibby and D. Pegg, with contributions by D. Carter and S. E. Miller and photographic color plates by B. D'Abrera. 2001. Brill Academic Publishers, Leiden, Netherlands. ISBN 90-04-11846-2. List Price: U.S. \$124, EUR 118, NLG 222.57

This important treatment of the Lepidoptera is part three of the Fauna Melesiana Handbook series. For those wanting the basic systematics, morphology and biology, and to identify families of butterflies and moths quickly and easily, this is the handbook for you. But it is much more than that. The scholarship and writing style provide historical and current perspectives of where interesting research questions lie. Although expensive, this well produced, solidly bound book will remain an important resource for research on Lepidoptera for many years to come.

Chapter 1 introduces principles and practices of classification, phylogenetic relationships, diversity, and biogeography of Malesian Lepidoptera. The tone is a balance of engaging enthusiasm for the Lepidoptera and a rigorous understanding of their systematics that is at a gentle simmer rather than a furious boil. Although the systematic techniques advocated utilize strict methods, they are elegantly interjected such that the reader is drawn in and convinced of their importance rather than bludgeoned in fundamentalist manner as in many modern treatments. This chapter also includes a useful section (contributed by D. Carter) on the practicalities of making, studying and managing collections.

Chapter 2 is a uniformly excellent summary of early stage and adult morphology supported with lucid, annotated illustrations. It demystifies the morphology of Lepidoptera such that one is eager to have a look for oneself. As such Chapter 2 is certain to be consulted repeatedly by veterans wanting comparative facts and reminders, and because of its clarity it will also inspire up-and-coming generations of lepidopterists. The direct, simple style of enthusiasm is once again more engaging than the obfuscated technicalities given in many texts of this type.

Chapter 3 is concerned with identification. Rather than simply presenting a key that is logical only to those who wrote it, the authors give a short review of previous identification keys pertinent to the fauna, and provide cautions for the beginning lepidopterist (or reminders to the veterans) that few specimens that come in for examination are "perfect"—perfection being an

implicit assumption in all keys. The authors engender a suspicion that one must develop an appreciation for the variation in specimen condition, and then through practice, a familiarity with the major groups, and eventually experience will aid the user in identifying the specimen at hand. In essence the authors acknowledge that mistakes are normal in the course of learning, and that one must learn to read between the lines of specimens, so to speak. To this end we are shown that certain characters in the key are important: venation, tymbal organs, head structures, and even resting postures of the live insects, but they may show variation, and this is interesting. Proceed to the keys with confidence. Here we find a no-nonsense approach that not only includes keys to adults, but subsequent treatments of larvae also point to important characters (not just technical ones) that easily separate various groups: prolegs, spines, hairs, filaments and beyond. Finally we are provided a summary of the foods caterpillars in major groups feed upon (leaves, bark, wood, roots, fungus, other insects, etc.), and the major themes of host plant associations in the various families.

Chapter 4 provides the banquet: detailed accounts of each family that offer pertinent taxonomic, behavioral and ecological characteristics for each group. The experience distilled over a lifetime study of the Lepidoptera supplies the rhythms, melody, tenor and tasteful improvisation. The accounts are extremely well done, and here I seem to detect Holloway's literary stamp—an inherent mixture of classical scholarship and awareness of new horizons.

We are offered eight color plates that are uniformly excellent. However, given the thoroughness and scope of the text (and the monetary price), one immediately asks the question, why so few? Whatever the constraints were during production it is unfortunate that this book was not allocated many more color plates. An increased number of plates would have gained a wider audience and amplified the accessibility of an already impressive work.

There are two appendices. The first compares species richness of families among relevant areas, and puts them into context of the world fauna. Those interested in comparative diversity will use this section. The second appendix is a comprehensively detailed tabulation of known pest species, thus providing an important resource for those with a leaning toward the agricultural.

And then there is the reference section. Admirable. Wonderfully rich. Redolent of quiet, vertical tasting within the cellars of classical scholars. One could, and should get lost within this section for years to come. What more can I say?



The two indexes, one to morphological and the second to the scientific names, are both equally good. However, confining the indexes only to these topics does omit some things in the behavioral and evolutionary realm that would be of interest to many users. For example, a favorite topic of mine, myrmecophily, is not in either index. Rather, the trait must be sought via browsing with prior suspicion in particular groups (some *Lycaenidae* and *Riodinidae*). But the fact that myrmecophily also occurs in other, less well-known groups (e.g., *Cyclotornidae*) cannot be accessed via the index, it must be stumbled upon. A general index would have been welcome and useful indeed.

It may be one of those humorous examples where British and Americans are 'divided by a common language', but I was puzzled by one word choice. In this book the term used to denote the need for experience to develop a "gestalt" to identify various groups has repeatedly and amusingly sprung unbidden to my mind. The fact that experience imparts the ability to correctly identify butterflies and moths by a "feel" is a very real phenomenon among experts. But using the word "jizz" to describe the result of that mental process (and including it in the index) conjures up dated, but seminal American hipster slang that typically means something altogether different. What an interesting experiment in linguistic evolution has been set in motion!

In sum, I believe this important handbook will inspire genuine enthusiasm for a hands-on research approach to topics concerned with *Lepidoptera*. We need more books of this type to counter the facile "look but don't touch" method of studying the natural world that is advocated by the popular media, and the authors are to be congratulated on their ability to rise above this. The serious students of *Lepidoptera* (current and future) who will make fundamental contributions toward understanding the natural world will thank the authors for this handbook.

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THE GEOMETRID MOTHS OF EUROPE, VOLUME 1, INTRODUCTION, ARCHIEARINAE, ORTHOSTIXINAE, DESMOBATHRINAE, ALSOPHILINAE, GEOMETRINAE, by Axel Hausmann. 2001. Apollo Books. Stenstrup, Denmark. 282 pp., 8 color plates. 17 cm by 24 cm. ISBN: 87-88757-35-8. Retail cost DKK 490,00 (approximately

USD 61.00). Hard cover. A 10% discount is offered to subscribers of the series when ordered from Apollo Books.

Before the 1968 reprint of Holland's *Moth Book* by Dover Press, it was not easy for many average persons in the U.S.A. to study moths, beyond the *Golden Nature Guide*. Shortly following Dover's 1968 reprint, Ronald W. Hodges (1971) gave us the first, *Sphingidae*, of several volumes in the exquisite *Moths of America North of Mexico* series. Charlie Covell's eagerly awaited *Field Guide to Eastern Moths* in 1984 was aimed at a general audience.

My fellow moth-enthusiast acquaintances often mention their awe at which the Europeans publish smartly produced, high quality, pithy, and easy to use books on moths, not only of a general nature, but also for the specialist. Such are two new books from Apollo Books; *The Geometrid Moths of Europe Volume 1*, and *The Sesiidae of Europe*. This is a review of the former.

Wow!! What a book! This is terrific. My first impression was "They did it again" or to be more specific "Peder Skou did it again." Skou's Apollo Books, long a publishing house of high quality scientific books is here again with another tome—one that will be referenced for many years to come. The European users of this book will have much more to say about the nomenclature and systematics. As a general volume on *Geometridae*, it is terrific. As a general volume on moths it is terrific. As a general volume on much of *Lepidoptera*, it is terrific.

Axel Hausmann, the author of Volume 1 is the Editor-in-Chief of a project planned to cover 6 volumes. Volume 1 is full of general information and an appeal for assistance with the remaining volumes.

When I first looked at this book I liked it. Then I scanned and began to see the goodies. Then I read it in detail, and I was overwhelmed. This is a must read for all persons interested in *Geometridae* anywhere. The introductory sections are an extremely valuable important read for all persons interested in *Lepidoptera*.

There are many reasons why I am so enthusiastic:

1. The distribution maps provide two sets of data simultaneously. Black dots show the exact sites of specimens examined for this publication. Gray shading shows where the species might be seen. The gray shading represents extrapolated distributions based on ideal habitats, known dispersal patterns, and previously published distributions.

2. The introductory sections provide information on many ancillary subjects, of interest to persons studying



Lepidoptera, but most often available only in more specialized publications. Do you want to know more about “r-strategists,” “K-strategists,” and the “r-K-continuum” of “bionomic strategy?” Information can be found here.

Do you want to know more about the dynamics of Zoogeography including areal expansions and areal regressions? Do you want to know more about morphology (structures) with definitions and illustrations of the areole, connate and anastomosis veins, sexual and seasonal dichroism, ommatidium, chaetosema, flagellum, tergum, sternum, papillae anales, colliculum, hypognathous, holometabolism, and cremaster without the need for several other books? It's all here.

3. The concept of cladistic analysis, with its own jargon (three examples are monophyly, paraphyletic, and plesiomorphic), often appears in journals and at meetings of Lepidopterists. For the initiated, including most persons with an avocational interest in butterflies and moths, the strange language is impenetrable for understanding. Not any more. Hausmann provides a dictionary of many common terms and their meanings followed by the application of the concept to the phylogeny of the Geometridae. This is not a course on cladistics, but it provides often-used terms in a context providing quick overview. These few paragraphs can be indispensable for understanding what the authors of more complicated papers are saying.

4. Hausmann explains the concepts of variation, seasonal variation, sexual variation, normal variation, all of which are richly illustrated with color photos.

5. A combination of photographs and drawing are used to illustrate structural features of adults, antennae, legs, genitalia, larvae, pupae, eggs, and other morphological characters. We often look at drawings because we understand a picture is worth 1000 words. Hausmann provides all methods of explaining and interpreting important features of Lepidoptera and Geometridae.

6. The concepts of species, subspecies, clines, hybrids, and normal variations are discussed.

7. I really like the sections on Taxonomy and Nomenclature. The taxonomy of the subfamilies of

Geometridae is given followed in a few pages with a brief lesson on nomenclature and the Code of Zoological Nomenclature (1999). Hausmann refers to the newest version of the code and defines terms such as synonymy, homonymy, priority, invalid names, availability of names, and the different kinds of types. We often see and use these terms. Here they are defined for quick reference. The caution that all is not always as it seems is also given in a few Problematic cases.

You can have all this for the low price of \$61.00 USD, but wait, there's more. The first 79 pages of the book are worth the purchase price, but when you buy this book you also get 130 pages of very well prepared species accounts, eight color plates, 18 pages of genitalia drawings, a systematic checklist, 20 pages of bibliography, and two indices, an Index to subjects and taxa, and an Index to Scientific Names. Hausmann doesn't miss anything. The text is full of literature citations for persons wanting more information. He individually credits each photographer and artist for the excellent text illustrations. It's all here.

The only thing missing is keys. I like well-prepared keys, and this book has no keys. The well-prepared diagnoses and discussions of similar species are a good replacement for the keys.

Overall the volume is pleasingly and expertly constructed. The decorative cloth cover is attractive, and the book is Smythe sewn. A Smythe sewn book has threads through the folds of the paper on the inside margin. A Smythe sewn book lies flat when open, and individual pages never fall out. The insides are clean, and clearly written with a comfortable typeface and large font. The color illustrations are very sharp. The production of the book is consistently very high quality.

I highly recommend this book for all persons interested in Lepidoptera. For persons studying Geometridae the taxonomy presented here is required. For all other persons, this is a great example of the qualities of a very good book. The information within is very valuable. This book is very good value.

ERIC H. METZLER, *The Ohio Lepidopterists*, 1241 Kildale Sq. N., Columbus, Ohio 43229-1306, USA.



## MANUSCRIPT REVIEWERS FOR 2001 (VOLUME 55)

Manuscript reviewers are anonymous contributors to the scientific rigor, clarity and quality of text and illustrations in the papers published by the *Journal of the Lepidopterists' Society*. The reviewers' input is always valuable, but their swift response was especially critical during a time when we needed to expedite the publication of volume 55. Let us hope such enthusiastic response continues to allow the *Journal* to grow in readership. On behalf of all authors and editorial staff of this *Journal*, respectful acknowledgements are given to the reviewers listed here. Asterisks denote those who reviewed two or more manuscripts.

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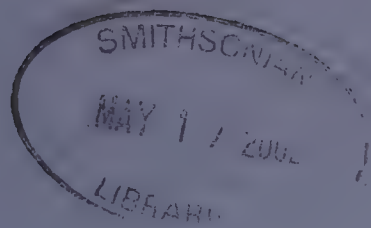


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# Journal of the Lepidopterists' Society



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**Cover illustration:** *Euphaedra edwardsi* (Nymphalidae), occurring from Sierra Leone to Nigeria and Cameroon. This specimen was photographed in Uganda by P. J. DeVries.



# JOURNAL OF THE LEPIDOPTERISTS' SOCIETY

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## WINSLOW J. HOWARD: PIONEER NEW MEXICO NATURALIST

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**ABSTRACT.** Winslow J. Howard arrived in Santa Fe, New Mexico in 1858. He helped found the original New Mexico Historical Society in 1859. Over the next 30 years Howard moved between mining towns, operating jewelry, watch-making and assay businesses in several states throughout the West. His longest stay in any one place may have been in Silver City, New Mexico, from 1880 to 1887. Howard's natural history interests included minerals, fossils, plants and insects. He collected some of the oldest documented butterfly specimens from Colorado and New Mexico. Howard was an important early amateur naturalist in the western United States and the first resident butterfly collector in New Mexico.

**Additional key words:** assayer, jeweler, history, naturalist, genealogy, patronym, natural history.

To modern New Mexico lepidopterists, W. J. Howard has been little more than a footnote associated with a few late 19th century butterfly records from southwestern New Mexico (e.g., Toliver et al. 1994:401). His role was preserved by Cockerell (1899), who discussed several New Mexico butterflies including "14 species collected by Mr. W. J. Howard in Grant County, N. M." Howard's modest lot consisted of *Adelpha bredowii* Geyer, *Eurema nicippe* (Cramer), *Colias eurytheme* Boisduval, *Zerene cesonia* (Stoll), *Chlosyne lacinia* (Geyer), *Euptoieta claudia* (Cramer), *Vanessa virginiensis* (Drury), *Vanessa cardui* (Linnaeus), *Nymphalis antiopa* (Linnaeus), *Thessalia theona* (Ménétriés), *Thessalia fulvia* (W. H. Edwards), *Danaus plexippus* (Linnaeus), and *Cercyonis pegala* (Fabricius). His specimen of *T. theona* is in the collection of the Biology Department at New Mexico State University. Most of these taxa are routine in southwestern New Mexico. Cockerell (1899) offered no clues about Howard's whereabouts, when Howard's specimens were collected, or how they came into Cockerell's possession. This author remained curious about Howard's identity and collecting activities in frontier New Mexico.

### MATERIALS AND METHODS

Howard provoked mild curiosity among historians and scientists over the years. Rocky Mountain biologists (i.e., Brown 1957, 1966) were curious about Howard's role as an early collector of specimens, some

of which became types. New Mexico historians (e.g., Bloom 1943, Torrez 1997) were curious because he helped to found the original New Mexico Historical Society. Though neither group benefited from the efforts of the other, their publications represent a collection of secondary sources that, when taken together, opened doors to valuable primary resources.

Old newspapers, originally noted by Brown as a key resource about Howard's activities, also proved vital in this present study. Microfiche copies of old newspapers were examined at the Museum of New Mexico's History Library (MNMHL) in Santa Fe, the New Mexico Records and Archives Center (NMRAC) in Santa Fe, and the Silver City Museum (SCM) in Silver City. Minutes of the New Mexico Historical Society were an important primary resource cited in Bloom (1943) and Torrez (1997). A third major primary source was the Special Territorial Census, conducted by the U.S. government in 1885 in preparation for eventual New Mexico statehood. This was reviewed on microfiche at the NMRAC. Information about Howard's early professional years in New York could not be located because Tiffany & Co. did not retain employee records of that vintage (L. Bann pers. com. 1999).

Information about Howard from the Special Census provided an entry point to genealogical records. Genealogical inquiries first were made through various internet sites. These led the author to the Reference and Genealogy Section of the New Hampshire State Library, which led to that state's Bureau of Vital Statis-



tics. Detailed research into New Hampshire files was not practical from the author's home in New Mexico, but that resource warrants future attention.

## RESULTS

Winslow J. Howard first came to the West in 1858 (Table 1). His arrival in Santa Fe, New Mexico, is documented by the following advertisement, which he submitted on 18 December 1858, and which was published in the Santa Fe Weekly Gazette of 5 February 1859. "Mr. W. J. Howard begs leave most respectfully to inform the citizens of Santa Fe and the public in general that he has taken a room in the placita of the Exchange Hotel for the purpose of repairing fine Watches of every description, also Clocks, Music Boxes, Jewelry, and other mechanical contrivances. By the practical experience of thirteen years in the business, and with the recommendation of the largest Jewelry Establishment in this country—the house of Tiffany & Co., New York city—he hopes to merit a share of public patronage in his line."

Howard's broad interests revealed themselves soon thereafter. On 15 December 1859, he was one of 25 people who met in Santa Fe, the territorial capitol, to found the New Mexico Historical Society. Commenting on the minutes of that meeting, Bloom (1943:242) remarked that Howard "was one of the prime movers in organizing the Society . . . he himself was made secretary of the meeting—and it was he who stated the object for which they had gathered . . . He was the first one named in the charter of incorporation." On 26 December Howard was elected Curator and Librarian and was asked to "take charge of and classify all Indian antiquities and curiosities; geological and mineralogical specimens; geographical maps, and objects of natural history" (Torrez 1997). Society records indicate that Howard resigned his office on 17 April 1860, and left Santa Fe to pursue business interests elsewhere (Torrez 1997).

His destination and activities for the next six years were illuminated by Brown (1957:45–47). While researching pioneer entomologists in Colorado, Brown found scattered references to specimens collected by Howard. Piecing clues together, Brown deduced that Howard was associated with mining camps. By reading old newspapers, Brown found an announcement in *The Western Mountaineer* of 19 July 1860, promoting Howard's new business in Denver. By 1862 Howard was in Central City, Colorado, where he and a partner manufactured jewelry under the name of Howard and Colony, whose newspaper advertisements continued until January 1865. Brown reported that Howard moved back East in late 1865, married, and took up

residence in Brooklyn, New York. He returned west in October 1866, traveling by stagecoach to Montana via Denver. After that, Brown found the trail of his "jeweler-naturalist" more difficult to trace. He reported evidence of Howard in Prescott, Arizona, in the 1870's and in Leadville, Colorado, in 1879 (Brown 1966:127), but he never found Howard's trail again.

Howard's life after 1866 remained a mystery until Torrez (1997) placed him in the mining town of Silver City, New Mexico, in 1880. Further research by SCM staff showed that Howard advertised frequently in local newspapers to promote his assay, jewelry and watch-making services (S. Berry, SCM, pers. com. 1997). He was sufficiently newsworthy to be the subject of at least two feature stories. One appeared on 10 June 1882, in *The New Southwest*, one of several newspapers then operating in Silver City: "[A] collection to which we would call special attention is that of W. J. Howard, assayer and jeweler, who has spent twenty-three years in the Rocky Mountains, and has devoted his leisure time to the study of metallurgy and natural history and who is a member of several scientific institutions." This article detailed his "rare and choice selections of crystallizations of metals and minerals." His was "the largest and finest collection of fossil shells ever collected in New Mexico from various localities, cemented on cards with their generic species named, besides butterflies and other insects, pressed flowers, leaves, etc."

The year 1883 witnessed the arrival in Silver City of telephones, electric streetlights and a branch railroad from the main line at Deming (Berry & Russell 1995:24–25). One newspaper article that year featured Howard as a prominent collector and dealer of ancient coins, which he occasionally sold in New York. Other details of Howard's life in Silver City were documented in the Special Territorial Census of 1885 (NMARC archives). A Silver City census-taker recorded "Howard, W.J.," as a married, literate, white male whose profession was assayer. The Census found Howard living in a boarding house with predominantly younger, unmarried men including a miner, a tinsmith, a laborer, a merchant, a butcher and three saloonkeepers. This arrangement was routine in frontier mining towns and was consistent with having a permanent home and wife in the East.

The Census listed Howard's birthplace as New Hampshire and the birthplaces of his father and mother as Massachusetts and New York, respectively. Howard's age was stated as 57 years, indicating he was born ca. 1828. This information provided a starting point for researching genealogical records. Searches for a Winslow J. Howard born in New Hampshire ca.



1828 were conducted on the internet in October 2001, but hours of automated searching through these considerable genealogical resources and databases produced no match. The Reference and Genealogy Section of New Hampshire State Library (NMSL) searched some of their files at the author's request. Library staff found no reference to Winslow Howard in the New Hampshire federal census for 1850, in Stearns' "Genealogy of New Hampshire," or in published Howard genealogies in the Library's collection (Z. Moore pers. com. 23 October 2001). Similarly, the New Hampshire Bureau of Vital Statistics (NHBVS) found no birth record for Winslow J. Howard (NHBVS pers. com. 8 November 2001).

Failure to locate Winslow J. Howard in New Hampshire genealogical records reflects two basic obstacles. First, genealogical records are incomplete. The NHBVS reported that many vital events of that era were never recorded (W. R. Bolton pers. com. 8 November 2001). Second, "Howard" and "Winslow" were popular family names in New England. Internet searches revealed one intermarriage between the two families, and there likely were others. The NHSL reported Howard surnames in 34 different New Hampshire towns in the early 19th century (Z. Moore pers. com. 23 October 2001).

Howard's financial fortunes waxed and waned with Silver City's mining-based economy. In 1886, he was tax delinquent on property worth \$400 (SCM archives 1998). Economic troubles worsened in 1887, causing one of Silver City's three banks to fail (Berry & Russell 1995:35). That year, Howard's regular newspaper notices assumed a different tone, stating in July 1887 that he sold his Silver City business and, in August, that he began a professional association with George Williams & Co. in Deming. There, Howard's newspaper trail ended. The author tried to trace Howard through the Deming Headlight, a newspaper that began publishing in 1882, but issues from 1883 to August 1888 could not be located in archives. Review of issues from September 1888 to April 1889 (MNMHL archives) disclosed no ads by Howard or by George Williams & Co.

#### DISCUSSION

Despite living on the western frontier, far from most professional scientists, Howard did not conduct his natural history work in a vacuum. He was a member of the Entomological Society of Philadelphia (Brown 1957) which later became the American Entomological Society. He collected the Colorado specimen used to describe a new species of bee (Cresson 1863) and he supplied Montana plant specimens to Asa Gray at Harvard (Brown 1957). Butterflies collected by

Howard were among the oldest documented Colorado specimens used by Tryon Reakirt to compile the first list of Colorado butterflies in 1866 (Brown 1957).

During Howard's time in New Mexico, he was linked to University of Kansas entomologist Francis H. Snow. In August 1884, Prof. Snow and his students visited Silver City to collect insects (S. J. Cary & R. Holland in prep.). Reporting on this expedition, Snow (1885:65) acknowledged "Mr. W. J. Howard of Silver City for many favors." Snow reported 13 butterflies and long lists of moths and beetles, remarking that the "electric lights at Silver City were very attractive to insects" (Snow 1885:69). One particular moth was listed as "*Daritis* sp. a superb species obtained from Mr. W. J. Howard, Silver City" (Snow 1885:66). For identification of unfamiliar Lepidoptera collected on this expedition, Snow (1885:65) relied on Henry Edwards. In describing the new moth as "*Daritis thetis*, Klug, var. *Howardi*" (Arctiidae: Pericopinae), Edwards (1886[1887]:165) noted that "About 2 years ago, I received from Mr. Wilson [sic] Howard, two specimens of this magnificent moth, which had been taken by him in New Mexico." Linkage of the type specimens from their collection by Howard, through Snow, to Edwards' description of *D. howardi* now warrants restriction of its type locality to Silver City, Grant County, New Mexico. No other patronyms were traced to Winslow J. Howard.

It has been suggested that Howard may have collected other specimens that survive today as anecdotal frontier New Mexico butterfly reports, for example from the Sacramento Mountains. While the timing of Howard's presence in New Mexico makes this connection theoretically possible, the author is unaware of any specific information to support it. Mining was not a big part of the frontier economy in the Sacramentos, making it difficult to imagine what would have attracted Howard to the area or how he could have supported himself as an assayer. Similarly, the author is not aware of any insect specimens collected by Howard during his 1859 sojourn in Santa Fe. Nevertheless, it is clear that more remains to be learned about Howard; additional research may disclose specimens and relationships that are not apparent today.

#### CONCLUSIONS

In addition to being a professional jeweler and assayer, Howard was an active naturalist who collected specimens that helped scientists describe the flora and fauna of the West. Howard appreciated the scientific value of his specimens, researched their identities and recorded generally where they were collected. Specimens collected by Howard ca. 1884 are among the



earliest reliable butterfly reports from southwestern New Mexico (Cockerell 1899). He helped University of Kansas Prof. F. H. Snow collect insects in Silver City in 1884 (Snow 1885). Although genealogical inquiries bore no fruit in this study and no evidence was found that he fathered any children, Howard's name lives on in the beautiful arctiid moth, *Daritis howardi* (Edwards 1886 [1887]).

The activities, contributions and lives of professional scientists of the historical period are documented in their publications and through records at their academic institutions. In comparison, the lives of most amateur naturalists and collectors usually were not systematically recorded, even though they supplied much of the raw material with which their professional contemporaries worked. It has been challenging to assemble the story of Winslow J. Howard because his faint footprints are scattered across several states, several decades and several scientific disciplines. Though his origins remain obscure, it is hoped that the above information contributes to the record of this important naturalist in New Mexico and the West.

#### ACKNOWLEDGEMENTS

The author is grateful to former New Mexico State Historian Robert Torrez, who catalyzed this article by providing the clue that parted the fog surrounding W. J. Howard in New Mexico. Susan Berry and Jim Carlson of the Silver City Museum were very helpful in review of Museum archives. Charles Martinez, of the New Mexico Archives and Records Center, helped identify, retrieve and interpret historical material. Tomas Jaehn assisted in research of files

in the Museum of New Mexico's History Library. Jane Ruffin looked for evidence of Howard at the Library of the Academy of Natural Sciences in Philadelphia. Greg Forbes found one extant Howard butterfly specimen in the collections of New Mexico State University. Richard Holland flagged *Daritis howardi* as a potential W. J. Howard patronym and Ron Hodges helped track down its original description. Ray Stanford shared his library. Tim Cary and Susan Berry critiqued early versions of the manuscript. The author is grateful to Richard Holland and an anonymous reviewer for constructive comments.

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## FIVE NEW SPECIES OF *DALLA* FROM COLOMBIA AND ECUADOR (HESPERIIDAE)

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**ABSTRACT.** Five new species of the Heteropteryne genus *Dalla* Mabille, 1904 are described and their male (and female where available) genitalia illustrated. Three of these species, *Dalla disconnexa*, new species, *D. vista*, new species, and *D. celsus*, new species are from Ecuador, the other two, *D. wardi*, new species and *D. pedro*, new species, from northeastern Colombia.

**Additional key words:** genitalia, transtilla, harpe, Heteropterini, *cypselus* group, *caenides* group.

When Evans compiled his catalog of the Hesperinae of America (Evans 1955), there were in the BMNH collection 1949 *Dalla* specimens representing 71 of the then known 75 species and 41 subspecies. Of these, only 29 specimens were females from 15 different species, and two of these females are the unique types of their species. He divided these 75 species into seven species groups, based on wing and leg characters, but not genitalia, resulting in some very unrealistic associations. Since the publication of Evans' masterpiece, 20 new species and two new subspecies have been described (*D. pota* and *D. cola* Bell, 1959; *D. ramirezi* Freeman, 1969; *D. roeveri*, Miller & Miller, 1972; *D. nubes*, *D. pincha*, *D. xantha*, *D. bos*, *D. pura*, *D. simplicis*, *D. puracensis*, *D. puracensis quindio*, *D. puracensis cotopa* and *D. calima* Steinhauser, 1991a; *D. kemneri* Steinhauser, 1991b; *D. steinhauseri* Freeman, 1991; *D. freemani*, Warren, 1997 and the five described below). Two subspecies, *D. epiphanaeus superior* Draudt, 1923 and *D. lalage lethaea* (Schaus, 1913) have been raised to specific rank by Steinhauser (1991a:5, 13), and one species, *D. dividuum* (Dyar, 1913) raised from synonymy with *D. ligilla* (Hewitson, 1877) by Freeman (1968:61) bringing the totals to 98 species and 41 subspecies.

In human-disturbed sites, males of the genus *Dalla* frequently gather on vertical or near vertical wet concrete surfaces, especially recently set concrete to feed on the mineral rich moisture exuding therefrom. They also congregate on wet soils where cattle have gathered, feeding on the nitrogen rich urine. I have found that urine added to vertical steep faces is a good bait, but I have never found females at any of these sites. They are either very rare or keep themselves well hidden, probably busy laying eggs to raise the next generation of males. *Dalla* species are not often found below 1500 m elevation, and usually above 2500 m. I know nothing of *Dalla* life history, food plants or immature stages, but it is probable that the larvae may feed on various grasses as recorded for *Carterocephalus palaeomon* (Pallas, 1771) by Tietz (1972:501) and Scott (1986:425), and for *Piruna pirus* (Edwards, 1878) and *P. aea* (Dyar, 1912) by Opler (1999:415–416).

While curating Hesperiid material at the Allyn Museum of Entomology, comparative genitalic examination with superficially similar taxa in conjunction with previous studies indicated that several of the many unidentified hesperiids specimens were indeed new species. As stated by Judith E. Winston (1999:115), "Once you have . . . satisfied yourself that the organism you are studying does indeed represent an undescribed species, your aim is publication. Only if it is named and described acceptably in a scientific publication will the species name be available for you and others to use. Descriptions of new species are still an important part of publication in the field of taxonomy." Therefore, in an effort to better document the Neotropical lepidopteran fauna, five new species in the genus *Dalla* Mabille, 1904, are described below. Nine other new species and two new subspecies in the genus were described earlier (Steinhauser 1991a, b).

*DALLA* MABILLE, 1904

**Diagnosis.** The genus *Dalla* is one of the six heteropteryne genera occurring in the New World. Most of its 98 species (this includes the five new ones herein described) are essentially montane in habitat and centered primarily in the Andes of South America, but extending also into Central America and Mexico. Evans (1955), the most recent reviser of the genus, used ten characters, unfortunately none of them genitalic, to distinguish among the six genera of the New World Heteropterini, which he included in the Hesperinae as the *Carterocephalus* group. He distinguished *Dalla* from the other five (*Carterocephalus*, *Piruna*, *Dardarina*, *Butleria* and *Argopteron*) by the apiculus of the antennae being "gradual, sharply pointed" rather than "blunt, more or less flattened and compressed at tip" as in the other five (Evans 1955:9–10). The other nine characters were used in various combinations to distinguish among the other five genera. None of their various states pertains uniquely to *Dalla*, which shares a relatively long antenna (equal or greater than half the forewing costa) with *Argopteron*, *Butleria* and *Dardarina*; spined midtibiae shared with *Carterocephalus*,



*Piruna*, *Dardarina* and *Butleria*; relatively short palpi (equal to head, rather than longer) shared with *Dardarina*; antennal nudum usually of more than 11 segments rather than less, shared with *Butleria*; nudum longer than half the antennal club, shared with *Dardarina* and *Butleria*; antennal club not grooved, shared with all but *Argopteron*. I found the other three characters used by Evans to apply inconsistently. For further comments on Evans' classification see Steinhauser (1991b:40–42).

#### MATERIALS AND METHODS

I have followed Evans' arrangement of the genus into groups in the placement of these new species, despite its unreality. Wing measurements are given to the nearest 0.5 millimeter, since I find it impossible to determine the exact wing base position on a mounted specimen more closely. Genitalic dissection techniques and terminology are the same as used by Steinhauser (1989). Wing venation follows the system of Miller (1972). The male genitalia of all five and the female genitalia of the one with a known (or probable) female are illustrated. Two of these new species are from the Santa Marta region of northeastern Colombia. The other three, two of which I had previously misidentified as *Dalla connexa* Draudt, 1923, are from Ecuador. All of these specimens are deposited in the Allyn Museum of Entomology.

#### *Dalla wardi* Steinhauser, new species

(Figs. 1, 2, 15)

**Male. Head:** Blackish brown above; palpi hairy, grizzled black and white, third segment (missing in holotype) slender, porrect, black, nearly hidden in hairs of second segment. Antennae about half costa, shaft prominently checkered black and yellow, club black, yellow at base, nudum brown, 11 segments in holotype (right antenna glued to paper triangle on pin), 12 segments in paratype; terminal segment short, pointed. **Thorax:** Blackish brown above, fulvous beneath. **Thoracic appendages:** Legs fulvous; foretibiae with long slender, brown epiphyses reaching and slightly overlapping tarsi; mid and hindtibiae spined, midtibiae with single pair of spurs, hindtibiae with two, the upper smaller. **Wings: Dorsal surface:** Forewing dark blackish brown, a few scattered yellowish hairs in basal third; yellowish white hyaline spots as follows: three contiguous, subequal subapical spots separated by dark veins in  $R_3$ – $R_4$ ,  $R_4$ – $R_5$  (smallest) and  $R_5$ – $M_1$  (largest), their inner edges in an arc convex proximad; triangular lower cell spot nearly reaching radius, centered between origins of  $R_1$  and  $R_2$ ; large rhomboid spot in  $Cu_1$ – $Cu_2$ , its edges in line with those of the cell spot and separated from it only by the dark cubital vein; small (circular in the holotype, rhomboid in the paratype) spot in mid  $M_3$ – $Cu_1$ , somewhat larger than the largest subapical spot. These hyaline spots are bordered by a very narrow line of orange yellow scales. In addition to the hyaline spots, there is an opaque rhomboid-to-near-triangular yellow spot in mid  $Cu_2$ – $2A$ , not reaching  $Cu_2$  and separated by about half its width from the spot in  $Cu_1$ – $Cu_2$ , its outer edge about in line with the inner edge of the combined cell plus  $Cu_1$ – $Cu_2$  spot. Fringes concolorous,

shading to paler brown and somewhat ochreous at tornus. Hindwing same dark brown as forewing, with a few orange yellow hairs in the basal quarter, and bearing a prominent, sharply defined, somewhat ovoid central orange spot, undivided by dark veins, in the cell, extreme base of  $Rs$ – $M_1$ ,  $M_1$ – $M_2$ ,  $M_2$ – $M_3$ , extreme base of  $M_3$ – $Cu_1$ , base of  $Cu_1$ – $Cu_2$  and  $Cu_2$ – $1A$ ; the portion of the spot in  $Cu_1$ – $Cu_2$  and  $Cu_2$ – $1A$  is shifted slightly basad from the rest of the spot. Fringes ochreous to orange, slightly paler at tornus. **Ventral surface:** Forewing centrally blackish brown, costa and apex broadly reddish brown, more or less heavily scaled yellowish in distal half of costal cell. Hyaline spots as above; opaque spot in  $Cu_2$ – $2A$  much larger than above, clear pale yellow, shares entire caudal edge of spot in  $Cu_1$ – $Cu_2$ , concave distally, convex proximally. Fringes reddish brown, shading to greyish at tornus. Hindwing reddish brown, dark grey in  $2A$ – $3A$  and anal cell. Central spot as above, clear orange yellow, sharply defined. Additional rather obscure opaque yellow spots in  $Sc$ – $R_1$ – $Rs$  about one third way from base, and subterminally in  $Cu_2$ – $2A$ . Fringes concolorous at apex, shading to ochreous at tornus. **Abdomen:** Blackish brown above, fulvous beneath. **Genitalia:** Very similar to *D. mesoxantha* (Plötz, 1884), *D. xantha* Steinhauser, 1991, *D. merida* Evans, 1955 and *D. frater* (Mabille, [1879]). Tegumen slender, oval, not hollowed above; uncus rather short, subequal to tegumen, slender and narrowly and shallowly bifurcate in dorsal view; in lateral view, not projecting dorsad at juncture with tegumen, slightly hooked at distal end, bearing prominent dorsal hair tuft. Gnathos well sclerotized, smooth, extends distad to about mid uncus. Valvae symmetrical, 2.4 times longer than wide, 1.8 times length of combined tegumen and uncus; harpe projects prominently cephalad as a slender dentate process with a straight rather than concave dorsal edge, completely overlapping the obliquely upturned distal portion of the ampulla which does not extend dorsad beyond harpe and bears a slender, inwardly projecting curved flange at its base. Penis slender, slightly shorter than valvae, distally broadened and dentate on left side; phallobase extremely short; single small, doubly dentate cornutus. Saccus very short, triangular; juxta and transtilla prominent.

**Female.** Unknown.

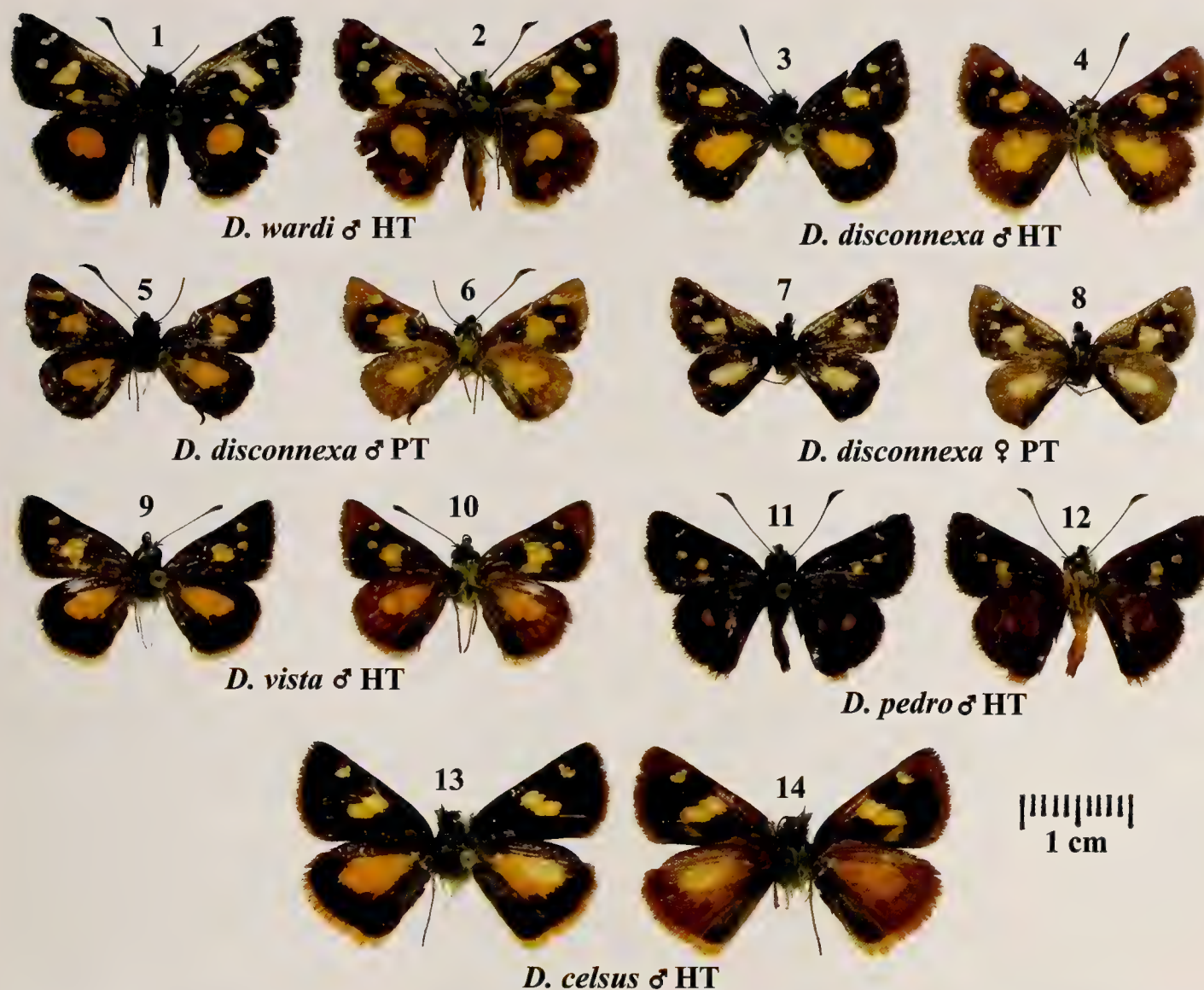
**Wing measurements.** Male forewing  $13 \times 7$  mm (paratype) to  $13.5 \times 7.5$  mm (holotype).

**Type material.** Holotype ♂, Colombia: Magdalena; 8 km E of San Pedro, 2550 m, 13-XII-1973, P. Ward & A. Forsyth, bearing the following labels: printed and hand printed white label, COLOMBIA: 8 km E of San Pedro Dept. Magdalena  $10^\circ 55'N$ ,  $73^\circ 58'W$  2550 m. 13.XII.1973 P. Ward, A. Forsyth; hand printed yellow label, [P.S. Ward photo slide No.] 7–19; white paper triangle with right antenna glued thereupon; printed and hand printed white label, Allyn Museum Acc. 1999-9; printed and hand printed red label, HOLOTYPE ♂ *Dalla wardi* S.R. Steinhauser; printed and hand printed white label Allyn Museum Photo No. 990724-13,14. There is one male paratype, same data as holotype; both of which are deposited in the Allyn Museum of Entomology.

**Etymology.** This handsome skipper is named for its discoverer, Dr. Philip S. Ward.

**Discussion.** *Dalla wardi* keys out to *D. mesoxantha* in Evans' (1955) key to the species of *Dalla*. It is a member of Evans' *cypselus* group and is most closely related to *D. mesoxantha*, *D. xantha*, *D. frater* and *D. merida*, but is smaller: 13–13.5 mm for *D. wardi*, 14–15 mm for *D. frater*, 15–15.5 mm for *D. mesoxantha* and *D. xantha*. The ventral hindwing reddish brown ground color of *D. wardi* is like that of *D. merida* and similar to that of *D. frater* and *D. meso-*





FIGS. 1–14. New *Dalla* species (odd numbers dorsal, even numbers ventral): 1, 2—*Dalla wardi*, new species, ♂ holotype; 3, 4—*Dalla disconnexa*, new species, ♂ holotype; 5, 6—*Dalla disconnexa*, new species, ♂ paratype; 7, 8—*Dalla disconnexa*, new species, ♀ paratype; 9, 10—*Dalla vista*, new species, ♂ holotype; 11, 12—*Dalla pedro*, new species, ♂ holotype; 13, 14—*Dalla celsus*, new species, ♂ holotype.

*xantha*, but unlike the dark brown of *D. xantha*. There is some question about the identity of *D. mesoxantha* (see Steinhauser 1991a:10), but until proven otherwise, I use the BMNH specimen from the Kaden collection marked "Type" as its model, though I have not seen its genitalia. The ventral hindwing maculation of *D. wardi* is like that of *D. mesoxantha* and *D. merida*, but the color of the central spot, both ventral and dorsal is more orange in *D. wardi* than in *D. mesoxantha* but not as deep orange as in *D. merida*. There is a more or less complete row of postdiscal pale spots in *D. frater*, lacking in *D. wardi*.

In the male genitalia, the uncus of *D. wardi*, viewed dorsally, is considerably more slender than in *D. mesoxantha* and *D. xantha*, but not as slender as *D. frater*; I have not seen the genitalia of *D. merida*, and

Evans' sketch does not make this feature clear. The forward edge of the uncus in *D. wardi* and *D. frater* does not project over the tegumen as it does in *D. mesoxantha* and *D. xantha*. The penis of *D. wardi*, like that of *D. frater*, is more slender than in *D. xantha* and *D. mesoxantha*, but, like them, much shorter relative to the valva length than *D. frater* (0.89 times valva for *D. wardi* and *D. mesoxantha*, 0.93 times for *D. xantha*, but 1.13 times for *D. frater*; the penis length of *D. merida* is not known). The dentate dorsal process of the harpe is very slender and slightly concave dorsally in *D. mesoxantha*, somewhat thicker in *D. xantha*, *D. frater* and *D. wardi*, strongly concave in *D. frater*, very strongly concave in *D. merida* according to Evans' sketch, only slightly concave in *D. xantha*, but straight in *D. wardi*. Only in *D. wardi* is the ampulla com-



pletely overlapped by the harpe, it projects dorsad beyond the harpe in the others.

### *Dalla disconnexa* Steinhauser, new species

(Figs. 3–8, 16, 17)

**Male. Head:** Blackish brown; palpi missing in type series of four males. Antennae (broken in holotype) slightly longer than half costa, shaft prominently checkered black and yellow, club black above, yellow beneath, nudum dark brown, 12 segments in two male paratypes with complete antenna, terminal segment long, pointed. **Thorax:** Blackish brown above, fulvous beneath. **Thoracic appendages:** Legs pale fulvous; foretibiae with minute brown central epiphyses; mid and hindtibiae spined, midtibiae with single pair of spurs, hindtibiae with two. **Wings: Dorsal surface:** Forewing dark blackish brown, a few scattered yellowish hairs in basal third; opaque yellow-orange (holotype) to pale yellowish white spots as follows: three contiguous, subequal subapical spots not separated by dark veins in  $R_3$ – $R_4$ ,  $R_4$ – $R_5$  and  $R_5$ – $M_1$ , their outer edges in a line directed toward mid termen; a more or less triangular lower cell spot, centered approximately between origins of  $R_1$  and  $R_5$ ; large rhomboid spot in  $Cu_1$ – $Cu_2$ , its inner edge in line with that of the cell spot and separated from it only by the dark cubital vein; small, more or less quadrate spot in  $M_3$ – $Cu_1$ , subequal to the subapical spots. These spots are slightly paler yellow-orange in one paratype and pale yellowish white in the other two. Fringes basally concolorous, distally paler brown, still paler at tornus. Hindwing same dark brown as forewing, with a few orange yellow (holotype) hairs in the basal quarter (pale yellow or missing in the paratypes), and bearing a prominent, fairly well defined, elongate ovoid central yellow-orange spot, undivided by dark veins and narrowed at its proximal end which nearly reaches the wing base, in the cell,  $M_1$ – $M_2$ ,  $M_2$ – $M_3$ , extreme base of  $M_3$ – $Cu_1$ , base of  $Cu_1$ – $Cu_2$  and  $Cu_2$ –1A; the portion of the spot in  $Cu_1$ – $Cu_2$  and  $Cu_2$ –1A is shifted slightly basad from the rest of the spot leaving a small dark notch distally on its rear edge. As on the forewing, the spot color varies in the paratypes. Fringes pale brown, shading to more orangish at tornus (yellowish to whitish in the paratypes). **Ventral surface:** Forewing centrally blackish brown, slightly paler in anal cell; costal cell, costa, apex beyond subapical spots and termen to  $Cu_1$  broadly reddish brown. Opaque spots as above, slightly paler; spot in  $Cu_1$ – $Cu_2$  extended patchily to 2A or 1A, variable. Fringes reddish brown. Hindwing reddish brown, dark grey with sprinkling of pale yellowish scales in 1A–2A, 2A–3A and anal cell. Central spot as above, but extending into Sc+ $R_1$ –Rs, filling the basal three fourths of that space, which bears, slightly distad of midpoint, a vague, reddish brown spot over-scaled yellow. There is some postdiscal, scattered yellow scaling, but not organized into a spot band. Fringes concolorous, slightly paler at tornus. **Abdomen:** Blackish brown above, fulvous to whitish beneath. **Genitalia:** Illustrated by Hayward (1943) and Evans (1955) as *D. connexa* (Hayward and Evans, nec Draudt 1923; see Mielke 1993:620, figs. 67–71 for correct rendition of *D. connexa* genitalia). Tegumen in dorsal view, oval, centrally constricted, not hollowed above; uncus rather short, in dorsal view oval, elongated distally to a narrow, bluntly pointed nose, in lateral view projecting dorsad and cephalad over tegumen, distally slightly hooked, bearing a dense dorsal hair tuft. Gnathos well sclerotized, smooth, extending caudad to beyond mid uncus, where it is surmounted dorso-distally by a broad, distally bifurcate, shagreened process wider than uncus and projecting caudad subequally. Valvae symmetrical, three times as long as wide, 1.7 times as long as combined tegumen/uncus length; harpe projects dorso-distally as a slender, curved process, coarsely dentate terminally and along its forward edge, only slightly overlap-

ping the ampulla which is evenly rounded and upturned dorsad, and distally elongated more or less evenly with the harpe. Penis slender, long (1.2 to 1.3 times valva length); phallobase short; cornutus a single, small, dentate process. Juxta and transtilla very prominent; juxta narrowly pointed cephalad; transtilla developed into two long pointed arms projecting caudad.

**Female. Head:** As male; palpi missing from both paratypes, antennae of the one paratype with complete antennae, as male. **Thorax and thoracic appendages:** Thorax and legs as male. **Wings:** Generally as male, dorsal surface wing markings slightly paler; ventral surface ground color, especially the hindwing, much paler, central spot pale yellow, postdiscal area densely covered with pale yellow scales, leaving a narrow reddish brown distal border to the central spot, most prominent in  $M_1$ – $M_2$  and  $M_2$ – $M_3$ , and a very narrow reddish brown terminal border before the fringe. **Genitalia:** Lamella postvaginalis a narrow, distally concave sclerotized process. Lamella antevaginalis consists of two lateral lobes. Antrum a moderately sclerotized, rather long, oval tube extending well forward of the lamella antevaginalis; ductus bursae with a slender, rather obscure internal sclerotized process at about mid point, well forward of the antrum. Corpus bursae consists of two spherical sacs in tandem connected by a narrow membranous neck; the forward sac simple, the more caudad sac with long, slender internal spines forming lateral signa. Ductus seminalis connected to mid ductus bursae ventrally.

**Wing measurements.** Male forewing  $11 \times 5.5$  to  $12 \times 6.5$  mm (holotype); female forewing  $11.5 \times 6$  to  $12 \times 6$  mm.

**Type material.** Holotype ♂, Ecuador: Cotopaxi; Milimbanco 3900 m, ix.1971, R. de Lafebre, bearing the following labels: printed white label, ECUADOR: COTOPAXI Milimbanco, 3900 m; ix.1971 R. de Lafebre; printed white label, A.C. Allyn Acc. 1972–2; printed and hand printed white label, Genit. Vial SRS-2543; printed and hand printed red label, HOLOTYPE ♂ *Dalla disconnexa* S.R. Steinhauser; printed and hand printed white label, Allyn Museum Photo No. 990724-7,8. There are three male and two female paratypes all by the same collector: 1 ♂ Ecuador: Pichincha; Niebli, NW slope of Vol. Pichincha, 3500 m, viii-1971; 1 ♂ Ecuador: Pichincha; Vol. Antisana, 2950 m, vii-1971; 1 ♂ Ecuador: El Oro; Bellavista, 550 m, v-1971; 1 ♀, Ecuador: Tungurahua; Bellavista nr. Baños, 1900 m, xii-1970; 1 ♀, Ecuador: Tungurahua, San Antonio, 1950 m, ix-1971.

**Etymology.** I have named this insect *D. disconnexa* because of its great similarity to, but differences from, *D. connexa*.

**Discussion.** See discussion of the new species described immediately below.

### *Dalla vista* Steinhauser, new species

(Figs. 9, 10, 18)

**Male. Head:** Blackish brown above; palpi hairy, basally black, grizzled black and white distally, third segment (missing in holotype and one male paratype) slender, porrect, black, nearly hidden in hairs of second segment. Antennae slightly longer than half costa, shaft prominently checkered black and yellow, club black above, yellow beneath, nudum dark brown, 12 segments in only male paratype with complete antenna (tips of apiculi broken off on holotype), terminal segment long, pointed. **Thorax:** Blackish brown above, fulvous beneath. **Thoracic appendages:** Legs pale fulvous; foretibiae with minute brown central epiphyses; mid and hindtibiae spined, midtibiae with single pair of spurs, hindtibiae with two. **Wings: Dorsal surface:** Forewing dark blackish brown, a few scattered yellowish hairs in basal third; opaque yellow-orange spots as follows: three contiguous, subequal subapical spots not separated by dark veins in  $R_3$ – $R_4$ ,  $R_4$ – $R_5$  and  $R_5$ – $M_1$ , their outer edges in a line directed





FIGS. 15–20. *Dalla* species genitalia (scale line = 1 mm). 15—*Dalla wardi*, ♂ paratype (Genit. Vial SRS-4804): a) tegumen, uncus, vinculum and associated structures, lateral; b) tegumen and uncus, dorsal; c) tegumen, uncus and gnathos, ventral; d) saccus, ventral; e) right valva, interior lateral; f) penis, cornutus, transtilla and juxta, dorsal; g) penis, cornutus, transtilla and juxta, lateral; 16—*Dalla disconnexa*, ♂ holotype (Genit. Vial SRS-2543): a) tegumen, uncus, vinculum and associated structures, lateral; b) tegumen, uncus and gnathos, dorsal; c) tegumen, uncus and gnathos, ventral; d) saccus, ventral; e) right valva, interior lateral; f) penis, cornutus, transtilla and juxta, dorsal; g) penis, cornutus, transtilla and juxta, lateral; 17—*Dalla disconnexa*, ♀ paratype (Genit. Vial SRS-5281), ventral. 18—*Dalla vista*, ♂ holotype (Genit. Vial SRS-5282): a) tegumen, uncus, vinculum and associated structures, lateral; b) tegumen and uncus, dorsal; c) tegumen, uncus and gnathos, ventral; d) saccus, ventral; e) right valva, interior lateral; f) penis, cornutus, transtilla and juxta, dorsal; g) penis, cornutus, transtilla and juxta, lateral; 19—*Dalla pedro*, ♂ paratype (Genit. Vial SRS-4805): a) tegumen, uncus, vinculum and associated structures, lateral; b) tegumen, uncus and gnathos, dorsal; c) tegumen, uncus and gnathos, ventral; d) saccus, ventral; e) right valva, interior lateral; f) penis, cornutus, transtilla and juxta, dorsal; g) penis, cornutus, transtilla and juxta, lateral. 20—*Dalla celsus*, ♂ holotype (Genit. Vial SRS-4797): a) tegumen, uncus, vinculum and associated structures, lateral; b) tegumen, uncus and gnathos, ventral; c) tegumen, uncus and gnathos, dorsal; d) saccus, ventral; e) right valva, interior lateral; f) penis, cornutus and juxta, dorsal (drawn from memory).



toward mid termen; a more or less triangular lower cell spot, centered approximately between origins of  $R_1$  and  $R_2$ ; large rhomboid spot in  $Cu_1$ – $Cu_2$ , its inner edge in line with that of the cell spot and separated from it only by the dark cubital vein; small spot in  $M_3$ – $Cu_1$ , subequal to the subapical spots (rhomboid in the holotype and one paratype and not reaching the base of  $M_3$ – $Cu_1$ , triangular in one paratype and reaching the base). Fringes light greyish brown with an orange tinge toward the tornus. Hindwing same dark brown as forewing, with a few orange-yellow hairs in the basal quarter, and bearing a prominent, fairly well defined, elongate ovoid central yellow-orange spot, undivided by dark veins and narrowed at its proximal end which nearly reaches the wing base, in the cell,  $M_1$ – $M_2$ ,  $M_2$ – $M_3$ , extreme base of  $M_3$ – $Cu_1$ , base of  $Cu_1$ – $Cu_2$  and  $Cu_2$ –1A; the portion of the spot in  $Cu_1$ – $Cu_2$  and  $Cu_2$ –1A is shifted slightly basad from the rest of the spot leaving a small dark notch distally on its rear edge. Fringes ochreous to orange, shading to more orange at tornus. **Ventral surface:** Forewing centrally blackish brown, slightly paler in anal cell; costal cell, costa, apex beyond subapical spots and termen to  $Cu_1$  broadly reddish brown. Opaque yellow-orange spots as above, slightly paler; subapical spots narrowly bordered distally by slightly darker reddish brown; spot in  $Cu_1$ – $Cu_2$  extended broadly to 2A, yellow-orange to vestigial vein 1A, whitish in 1A–2A. Fringes reddish brown. Hindwing reddish brown, dark grey with sprinkling of pale yellowish scales in 1A–2A, 2A–3A and anal cell. Central spot as above, more or less overscaled reddish brown, poorly defined, marked with a vague reddish brown line at cell end. There is a very vague yellowish postdiscal spot-band from about  $Rs$ – $M_1$  to  $Cu_1$ – $Cu_2$ , which may be reduced to a few yellow scales. Fringes concolorous, slightly paler at tornus. **Abdomen:** Blackish brown above, fulvous beneath. **Genitalia:** Tegumen slender, oval, not hollowed above; uncus rather short, in dorsal view oval, elongated distally to a narrow, bluntly pointed nose; in lateral view projecting dorsad and cephalad over tegumen, distally slightly hooked, bearing a dense dorsal hair tuft. Gnathos well sclerotized, smooth, extending caudad to about mid uncus, where it is surmounted dorso-distally by a rounded, distally somewhat excavate, shagreened process narrower than uncus. Valvae symmetrical, three times as long as wide, 1.6 times as long as combined tegumen/uncus length; harpe projects dorso-distally as a slender, smooth pointed process with a single, centrally placed, short, inwardly projecting tooth; ampulla distally elongated, evenly rounded, bearing a narrow, curved, inwardly projecting flange at its base, overlapped by harpe process which does not reach dorsad beyond mid ampulla. Penis slender, long (1.4 times valva length); phallobase short; cornutus a single, small, dentate process. Juxta and transtilla very prominent; juxta narrowly and bluntly pointed cephalad; transtilla developed into two long pointed arms projecting caudad.

**Female.** Unknown.

**Wing measurements.** Male forewing  $11.5 \times 6$  mm (one paratype) to  $12 \times 6$  mm (holotype and one paratype).

**Type material.** Holotype ♂, Ecuador: El Oro; Bellavista 550 m, V-1971, R. de Lafebre, bearing the following labels: printed white label, ECUADOR: EL ORO; Bellavista, 550 m; v.1971 R. de Lafebre; printed white label, A.C. Allyn Acc. No. 1972-6; printed and hand printed red label, HOLOTYPE ♂ Dalla vista S.R. Steinhäuser; printed white label, Genit. Vial No. SRS-5282; printed and hand printed white label, Allyn Museum Photo No. 990724-3.4. There are two male paratypes, all same collector as holotype, 1 ♂ same data as holotype, 1 ♂ Ecuador, Tungurahua; Baños, 1850 m, xii-1970. The holotype and paratypes are deposited in the Allyn Museum of Entomology.

**Etymology.** The name *vista* is based on the last part of the name of the village where the holotype was collected.

**Discussion.** I had determined a series of seven males (two dissected) and two females (one dissected) from Ecuador at the Allyn Museum as *D. connexa*, based on Evans' (1955) key and description and his and Hayward's (1943) genitalia drawings. When later compared with Mielke's (1993) illustration of the genitalia of the lectotype of *D. connexa*, it appeared that those two males whose genitalia I had examined might be different; they had a prominent, bifurcate transtilla like that illustrated by both Evans and Hayward, and the dorsal harpe process was prominently and coarsely dentate along its entire forward edge, unlike that shown by Mielke with only some fine terminal dentation. Mielke did not illustrate the juxta and transtilla, and did not remember seeing (pers. com. 1999) a prominent, bifurcate transtilla. Upon dissecting the abdomens of the remaining specimens in the series, I discovered that three of the males were entirely different (*D. vista*); the other two were the same as the two I had originally determined as *D. connexa*, newly described above as *D. disconnexa*. I am treating the females as *D. disconnexa* because, although the central yellow spot of the hindwing beneath is more or less obscurely defined as in the males of *D. vista*, and not as well defined as in *D. disconnexa* males, it does extend fully into  $Sc+R_1$ – $Rs$ , and does not have a reddish brown bar at cell end. It is possible, however, that they may belong to *D. vista* instead.

It is very probable that the skippers determined as *D. connexa* by both Hayward and Evans, at least those whose genitalia were examined, are *D. disconnexa* rather than *D. connexa*. I have before me, however, a photograph of an undissected BMNH specimen from Colombia, determined by Evans as *D. connexa*, that I believe is probably *D. vista*.

Superficially, I find it very difficult to distinguish among the three species. All are about the same size (11–12 mm forewing) and have essentially the same wing markings. Comparing the Seitz illustration of *D. connexa* (Vol. 5: pl. 179e), and a photo taken by Mielke of the lectotype, with the series before me of *D. vista* and *D. disconnexa*, and a photograph of the BMNH specimen mentioned above, determined by Evans as *D. connexa*, I find the following slight and perhaps inconsistent differences:

Dorsal surface: spot in  $Cu_1$ – $Cu_2$  of forewing may be slightly larger in *D. vista* and *D. disconnexa* than in *D. connexa*. Color of the spots in *D. disconnexa* varies from yellow-orange to yellowish white; *D. connexa* is illustrated as yellow-orange similar to *D. vista*. The hindwing central spot of *D. connexa* and *D. disconnexa* is slightly longer (extends closer to termen) than that of *D. vista*.



Ventral surface: in the Seitz illustration, the hindwing central spot of *D. connexa*, which may be of the female, is very large, nearly white and fairly well defined. That of *D. disconnexa*, which may be whitish, is equally well defined, but very much smaller, whereas that of *D. vista* is rather poorly defined and generally slightly darker. The central spot in *D. vista* does not extend into Sc+R<sub>1</sub>-Rs as in *D. disconnexa* and has a reddish brown bar at cell end, missing in *D. disconnexa*.

Both of these new species belong in Evans' (1955) *caenides* group, and both will key to *D. connexa* in his key to the *Dalla* species.

### *Dalla pedro* Steinhauser, new species

(Figs. 11, 12, 19)

**Male. Head:** Dark brown above; palpi missing from both holotype and paratype; antennae reach to slightly beyond mid costa, shaft prominently checkered yellow and black, club black above pale yellow beneath, nudum brown, 12 segments, terminal segment short, rounded. **Thorax:** Dark brown above, beneath clothed in long pale fulvous hairs. **Thoracic appendages:** Legs clothed in long pale fulvous hairs; foretibiae with very small central epiphyses, mid and hindtibiae spined, midtibiae with single pair of spurs, hindtibiae with two pairs. **Wings:** Dorsal surface: Forewing dark brown with scattered ochreous hair scales in basal third. Small opaque, subapical yellow-orange spots in R<sub>3</sub>-R<sub>4</sub>, R<sub>4</sub>-R<sub>5</sub> and R<sub>5</sub>-M<sub>1</sub> in a line directed toward mid termen; slightly larger (up to 1 mm), widely separated, round, opaque yellow-orange spots in M<sub>3</sub>-Cu<sub>1</sub> and Cu<sub>1</sub>-Cu<sub>2</sub>. Fringes concolorous, shading to paler dull orange at tornus. Hindwing same dark brown as forewing, with scattered ochreous hair scales in basal third; small central orange spot in cell end extending into basal Rs-M<sub>1</sub>, M<sub>1</sub>-M<sub>2</sub> and M<sub>2</sub>-M<sub>3</sub>. Fringes dull orange. Ventral surface: Forewing same dark brown as above, slightly paler in anal cell, broadly rufous at costa, apex and termen to Cu<sub>1</sub>. Opaque yellow-orange spots as above, those in M<sub>3</sub>-Cu<sub>1</sub> and Cu<sub>1</sub>-Cu<sub>2</sub> much larger, quadrate; an additional opaque pale yellow spot in Cu<sub>2</sub>-2A adjoining the spot in Cu<sub>1</sub>-Cu<sub>2</sub>. Fringes as above. Hindwing rufous, black brown in anal cell; faint darker brown postdiscal spot band from Sc+R<sub>1</sub>-Rs to Cu<sub>1</sub>-Cu<sub>2</sub>. Fringe rufous with a faint dark brown hairline at its base. **Abdomen:** Dark brown above, rufous beneath. **Genitalia:** Tegumen broad in dorsal view, somewhat quadrate in lateral view, slightly hollowed dorsally. Uncus slender, entire, slightly hooked at distal end, projects over tegumen where it bears a very dense hair tuft. Gnathos broad, sclerotized, smooth, but bearing a large, bifurcate, dentate dorsal process that extends caudad as far as does the uncus. Valvae symmetrical, long (1.5 times combined tegumen/uncus length), narrow (length 2.5 times its greatest width); harpe projects dorsad as a short dentate nose, reaching mid ampulla, which is large, evenly rounded and extending caudad nearly as far as harpe. Penis long, slender, curved to left, terminally widened to left; phallobase very short; cornutus a small, monodentate plate. Juxta and transtilla prominent, transtilla with short, bilateral caudally directed projections. Saccus a small slender triangle.

**Female.** Unknown.

**Wing measurements.** Male forewing 12.5 × 6.5 mm (holotype) to 13 × 7 mm (paratype).

**Type material.** Holotype ♂, Colombia: Magdalena; 8 km E of San Pedro, 2550 m, 13-XII-1973, P. Ward & A. Forsyth, bearing the following labels: printed and hand printed white label, COLOMBIA: 8 km E of San Pedro Dept. Magdalena 10°55'N, 73°58'W 2550

m. 13.XII.1973 P. Ward; hand printed yellow label [P.S. Ward photo slide No.] 7-21; printed and hand printed white label, Allyn Museum Acc. 1999-9; printed and hand printed red label, HOLOTYPE ♂ *Dalla pedro* S.R. Steinhauser; printed and hand printed white label Allyn Museum Photo No. 990724-11,12. There is one male paratype, Colombia: Magdalena; 10 km E of San Pedro, 2900 m, 23-XII-1973, P. Ward; both types are deposited in the Allyn Museum of Entomology.

**Etymology.** This skipper is named for its locale, San Pedro.

**Discussion.** *Dalla pedro* does not fit well into Evans' 1955 key to the species of *Dalla*. I place it tentatively in Evans' *caenides* group on the basis of its rather peculiar genitalia, similar to *D. connexa* Draudt, 1923, *D. ticias* (Mabille, 1897), *D. caenides* (Hewitson, 1868), *D. bos* Steinhauser, 1991, *D. mora* Evans, 1955 and *D. carnis* Evans, 1955, none of which even faintly resembles *D. pedro* superficially. *Dalla pedro* bears some superficial similarity to several of the more sparsely marked *Dalla* species, but is immediately recognized by its distinctive genitalia.

### *Dalla celsus* Steinhauser, new species

(Figs. 13, 14, 20)

**Male: Head:** Black-brown above; palpi and antennae missing. **Thorax:** Black-brown above, reddish brown beneath. **Thoracic Appendages:** Legs dark brown, clothed in ochreous hairs and scales; fore and mid legs missing, hindtibiae spined with two pairs of spurs. **Wings:** **Dorsal surface:** Forewing black-brown with scattered ochreous scaling in the basal quarter, most prominent along the costa. Opaque yellow-orange spots subapically in R<sub>3</sub>-R<sub>4</sub> (smaller), R<sub>4</sub>-R<sub>5</sub> and R<sub>5</sub>-M<sub>1</sub>, in a line directed toward mid termen; broad cell spot across mid cell, its somewhat excavate outer edge centered between R<sub>1</sub> and R<sub>2</sub>; large, somewhat elongate spot in Cu<sub>1</sub>-Cu<sub>2</sub>, its outer edge convex, its inner half conjoined to the cell spot. Fringe paler brown. Hindwing same black-brown as forewing, overlain with orange hairs in basal one third, bearing a large, tear-drop-shaped orange spot nearly reaching wing base in cell, bases of Rs-M<sub>1</sub>, M<sub>1</sub>-M<sub>2</sub>, M<sub>2</sub>-M<sub>3</sub>, M<sub>3</sub>-Cu<sub>1</sub>, Cu<sub>1</sub>-Cu<sub>2</sub> and extending slightly into Cu<sub>2</sub>-1A and Sc+R<sub>1</sub>-Rs. Fringes brownish orange. Ventral surface: Forewing centrally dull black, reddish brown along costa to about cell end and at apex; spots as above, some yellow scaling at costa above cell spot; rather faint narrow yellowish spot in Cu<sub>2</sub>-2A, adjoining spot above it in Cu<sub>1</sub>-Cu<sub>2</sub>, narrow at Cu<sub>2</sub>, broader at 2A. Fringe red-brown, paler basally. Hindwing reddish brown, blackish in Cu<sub>2</sub>-2A and anal cell; spot from above yellowish, very faint, indistinct. Fringe concolorous, shading to orange at tornus. **Abdomen:** Blackish brown above, reddish brown beneath. **Genitalia:** Tegumen short, broad, globular; uncus short, broad, dorsally hollowed, its distal end broad, rounded, slightly concave centrally and extending laterally as two blunt points; the uncus is surmounted by two large circular lobes, densely hairy and projecting prominently dorsad. Gnathos shagreened, broad as uncus, rounded, slightly excavate centrally at caudal end, and extends caudally beyond uncus. Valvae symmetrical, harpe distally an upright process which is finely serrate along its distal margin, the teeth pointing inward. The harpe extends dorsad subequally with the rather squared, dorsally pointed ampulla, which, in interior view, overlaps the harpe rather than the more usual harpe overlapping the ampulla. Penis (lost while transferring to second watch glass and drawn immediately from memory) long, slender, with very short phallobase, slightly flared to the left distally and with a single small,



dentate cornutus. Juxta (lost with penis and drawn from memory) prominent, projecting prominently cephalad; transtilla (lost with penis and drawn from memory), not projecting prominently caudad.

**Female.** Unknown.

**Wing measurements.** Holotype male forewing  $15 \times 7.5$  mm.

**Type material.** Holotype ♂, Ecuador: Chimborazo; Atzatapungu, 4100 m, vi, 1976, R. de Lafebre, bearing the following labels: printed white label, ECUADOR: CHIMBORAZO Atzatapungu, 4100 m vi.1976; R. de Lafebre; printed white label, A.C. Allyn Acc. 1976-8; printed and hand printed white label, Genit. Vial SRS-4797; printed and hand printed red label, HOLOTYPE ♂ *Dalla celsus* S.R. Steinhauser; printed and hand printed white label, Allyn Museum Photo No. 990724-1,2. Known only from the holotype which is deposited in the Allyn Museum of Entomology.

**Etymology.** This skipper is named *celsus*, Latin for lofty, due to the high altitude of its type locality.

**Discussion.** In Evans' (1955) key to the species of *Dalla*, *D. celsus* falls into the *caenides* group, between *D. seiroides* Draudt, 1923 and *D. pantha* Evans, 1955, its hindwing spot extending slightly into  $Sc+R_1-Rs$ , unlike *D. seiroides*, but not reaching  $Sc+R_1$ , as in *D. pantha*. Another superficially similar species is *D. simplicis* Steinhauser, 1991 which lacks the ventral surface forewing spot in  $Cu_2-2A$ . Genitally, *D. celsus* is closest to *D. seiroides*, *D. puracensis* Steinhauser, 1991 and *D. ochrolimbata* Draudt, 1923 in having prominent dorsal lobes surmounting the uncus. *Dalla ochrolimbata* was placed by Evans in the *quadristriga* group because of its nearly complete lack of dorsal surface markings. *Dalla celsus* differs from both *D. seiroides* and *D. ochrolimbata* in the terminal shape of the uncus: broad and rounded in *D. celsus* and *D. puracensis*; with a bluntly pointed nose in *D. seiroides* and *D. ochrolimbata*. It also differs from them in the general shape of the valvae, which are terminally deeply excavate in *D. seiroides* and *D. ochrolimbata*. There are many other differences, but these serve to separate the species.

#### CONCLUSIONS

The genus *Dalla*, in fact the entire Heteropterini tribe, is in need of a phylogenetic revision. For example, I suspect that a few species currently in *Dalla* may belong in *Piruna*. It is also possible that some named *Dalla* taxa may be mere infraspecific variants; Evans (1955:20), speaking of his *agathocles* group, notes "The genitalia of the following 8 species are too alike to confirm their validity as species." Two of those eight species were then given an additional two subspecies and one of them, an additional three, making 15 taxa with essentially identical genitalia. Whereas this is entirely possible, it does seem like a ripe field for more detailed investigation. Unfortunately, at the present time, lack of comparative material from varied locations plus the extreme scarcity of females in col-

lections, makes such a study very difficult. If there are more undescribed species hiding in collections, they should be described and published to add to the data available for a possible revision. Whether this will result in subdividing *Dalla* into more than a single genus or to the establishment of sub-genera, I cannot say. There is a good possibility of arranging the species into groups based on genitalic similarity, shape and form of the antennal apiculus and club, form of the foretibial epiphyses and very probably other characters as well, certainly female morphology and immature biology. I have accumulated a fair amount of data, drawings and photos, which I will gladly share with anyone who decides to tackle this project.

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## THE COLLAPSED EGGS FOUND IN THE BURSA COPULATRIX OF A PLUM MOTH, *ILLIBERIS ROTUNDATA* JORDAN (ZYGAENIDAE: PROCRIDINAE): AN UNUSUAL EGG RESORPTION SYSTEM?

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**ABSTRACT.** In a plum moth, *Illiberis rotundata* Jordan (Zygaenidae), collapsed eggs and empty chorions were usually found in the bursa copulatrix. Effects of the number of these eggs on female longevity were analyzed with female body weight, body weight of her mate, and female fecundity. The results of multiple regression analysis showed that females with more eggs in the bursa copulatrix lived longer. It is most likely that eggs are resorbed in the bursa copulatrix and used for the survival of the females. This moth seems have an unusual egg resorption system.

**Additional key words:** oocyte, longevity.

Egg resorption, a specific type of reproductive tactic in which oocytes degenerate instead of being laid as eggs, has been reported in many insects (Bell & Bohm 1975), including lepidopteran species from groups such as Heliconiinae (Dunlap-Pianka et al. 1977) and other Nymphalidae (Boggs & Ross 1993).

*Illiberis rotundata* Jordan (Zygaenidae) is a univoltine and diurnal moth. Larval host plants include cherries, plums and other Rosaceae trees. Adults emerge from May to June in western Japan, and copulate and oviposit repeatedly almost for a month, taking only water (CK unpublished data). During the process of a study on mating behavior of *I. rotundata*, we found many collapsed eggs in the bursa copulatrix of females. In this paper, we describe this unusual phenomenon and suggest a possible function of these eggs.

### MATERIALS AND METHODS

We collected pupae of *Illiberis rotundata* in Naruto City (34°11'N, 134°35'E) in May 2000. Each individual was kept separately in a paper cup (7 cm diameter, 7 cm depth) placed in a constant condition room at  $21 \pm 1^\circ\text{C}$  with a 15L:9D photoperiod. After emergence, all adults were weighed using an electric balance (Sartorius AG) with an accuracy of 0.01 mg. Nineteen females were allowed to copulate once one day after emergence and five females were kept unmated through their lives (the laboratory females). Each mated female was moved to and kept in a plastic case (9 cm diameter, 5 cm depth) supplied with a single fresh cherry leaf (*Prunus × yedoensis*) and water. These females were allowed to lay eggs until death. Each cherry leaf was renewed every evening after the number of eggs laid by the female on that day had been checked. We dissected these females soon after their deaths and examined the contents of the bursa copulatrix. In 2001, we also collected and dissected females from the field (the wild females).

In order to reveal the function of the eggs in the bursa copulatrix, we examined their effects on female longevity. We selected four factors that might affect fe-

male longevity: female body weight (body weight of each female when she emerged), male body weight (body weight of her mate when he emerged), fecundity (total number of eggs each female laid during her lifetime) and the number of eggs (in any condition, see results) in the bursa copulatrix. Before further analyses, each value of female body weight, male body weight, fecundity and the number of eggs (+1) in the bursa copulatrix was log-transformed.

We analyzed correlation structures between these factors and longevity. Multiple regression analysis was also used to estimate only the direct effects of each factor on female longevity, using female longevity as the dependent variable, and the four factors as the independent variables. Data were analyzed using the StatView 5.0 (SAS Institute Inc.).

### RESULTS

We dissected 22 laboratory females and 21 of them (95.5%) had eggs in their bursa copulatrix (Fig. 1). We found a few spheroid shaped eggs, several collapsed eggs, and many empty eggs including fragmented chorions (Fig. 1b). The spheroid eggs were observed near the ductus bursa, whereas the empty eggs were at the bottom of the bursa. In one female, a spheroid egg was also observed in the ductus seminalis. We could not recognize any distinct spermatophore. The fat body had almost been depleted at death.

The number of eggs, including spheroid, collapsed and empty eggs, in the bursa copulatrix varied from zero to 52 in the laboratory females (Mean  $\pm$  SD =  $11.4 \pm 12.8$ , N = 19). In many cases, the bursa contained some other small fragmented chorions, thus the counted number of eggs seems to be underestimated. Among those 19 females, longevity was  $23.6 \pm 6.0$  days (Mean  $\pm$  SD), fecundity was  $461.1 \pm 177.3$ , body weight was  $53.7 \pm 8.8$  mg, and body weight of their mates was  $31.6 \pm 3.4$  mg.

The number of eggs in the bursa copulatrix and female body weight were positively correlated with female longevity (Table 1, Fig. 2), but fecundity was neg-



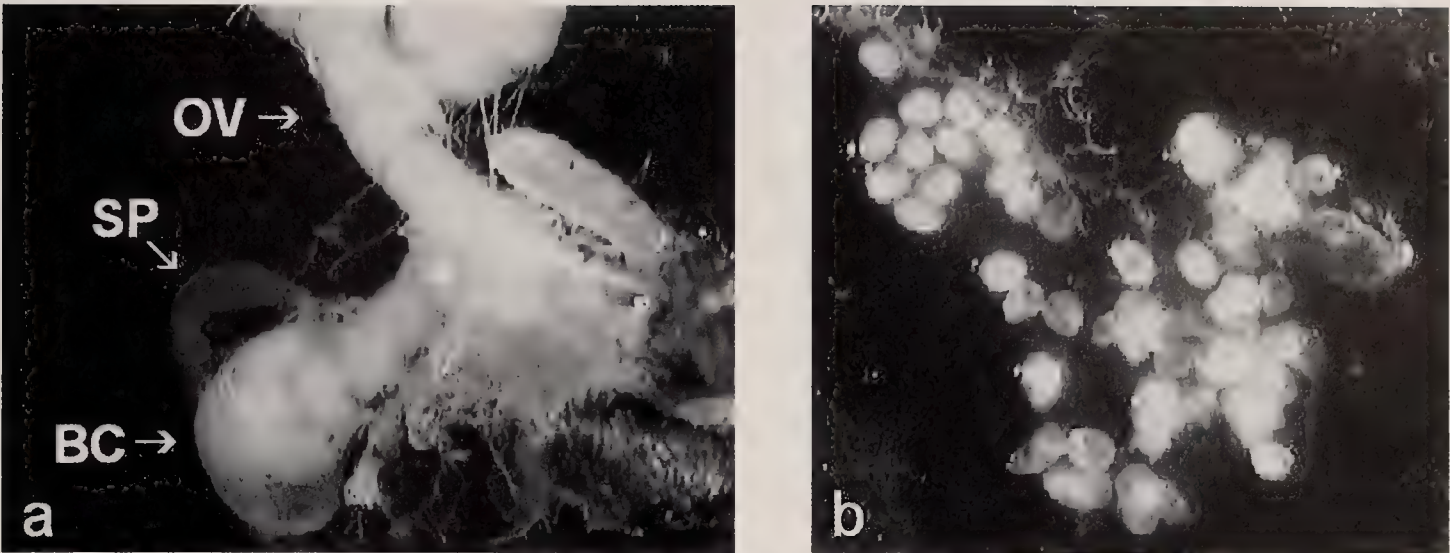


FIG. 1. The bursa copulatrix containing eggs in the laboratory females. (a) Many eggs contained are visible through the translucent wall of the bursa (BC, bursa copulatrix; OV, oviduct; SP, spermatheca). After dissection of this bursa, 9 collapsed and 18 empty eggs were counted. (b) Spheroid, collapsed or empty eggs from the bursa of another female.

actively correlated with female longevity. Fecundity was also positively correlated with female body weight ( $r = 0.46$ ,  $P = 0.046$ ). Fecundity and number of eggs in the bursa, however, showed no significant correlation ( $r = -0.36$ ,  $P = 0.13$ ).

The total multiple regression model was highly significant ( $R^2 = 0.82$ ,  $F = 15.5$ ,  $P < 0.0001$ ; Table 1). Both the number of eggs in the bursa and female body weight positively influenced female longevity. Fecundity negatively affected female longevity, suggesting a phenotypic cost of reproduction (see Reznick 1985). Male body weight had no effect on female longevity.

There is no significant correlation between fecundity and the number of eggs in the bursa, partialling out longevity (partial  $r = 0.129$ ,  $P = 0.59$ ,  $N = 20$ ).

Nine out of 16 wild females that had been collected in the field also had collapsed eggs or chorions in their bursa copulatrix. Seven of the nine females had one or two eggs, while two females had highly degenerated chorions that could not be counted. These observations indicate that retention of eggs in the bursa copulatrix is not caused artificially by keeping females in the laboratory for long periods. However, the number of

retained eggs found in wild females (Mean  $\pm$  SD =  $0.64 \pm 0.75$ ,  $N = 14$ ) was smaller than that of the laboratory females (Mann-Whitney's  $U$ -test,  $U = 13.5$ ,  $P < 0.0001$ ).

DISCUSSION

Resorption usually occurs in immature eggs (oocytes) within the ovarioles (Bell & Bohm 1975). On the other hand, the resorption of mature eggs (chorionated eggs) has been reported in Heliconiine butterflies (Dunlap-Pianka et al. 1977) and other insects (see Bell & Bohm 1975).

In most laboratory females of *I. rotundata*, collapsed eggs with chorions were found in their bursa copulatrix at death. To the best of our knowledge, such a phenomenon has never been documented in Lepidoptera. At this point we might ask, what is the function of these eggs? Eberhard (2000) found a mature egg or a larva just hatched from the egg in the bursa copulatrix in some female *Microsepsis armillata* (Diptera: Sepsidae) flies, and he also reported the same phenomenon in other flies. He suggested that the egg or larva would prevent intromission by a male, even though in these species females are immune to

TABLE 1. Results of correlation and multiple regression analysis for female longevity and factors potentially affecting the longevity. The total multiple regression model was highly significant (see text).  $r$ : correlation coefficient.  $\beta$ : standardized partial correlation coefficient.

Factor	Correlation		Multiple regression		
	$r$	$P$	$\beta$	$t$	$P$
Female body weight	0.29	0.232	0.49	3.55	0.003*
Male body weight	0.21	0.391	0.06	0.53	0.607
Female fecundity	-0.52	0.023	-0.55	-3.68	0.003*
Number of eggs in bursa	0.76	<0.001*	0.50	3.81	0.002*

\* Significant after using the sequential Bonferroni correction.



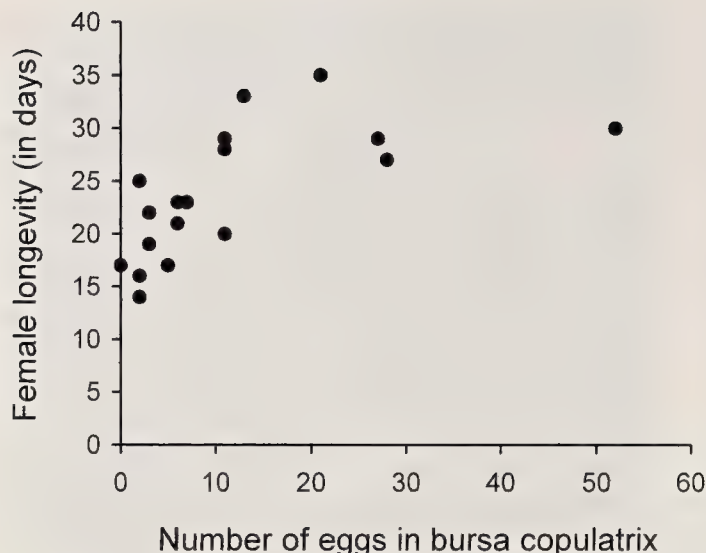


FIG. 2. The relationship between the number of eggs in the bursa copulatrix and female longevity.

rape. In *I. rotundata*, females are usually polyandrous and these eggs in the bursa copulatrix would not prevent intromission by males.

The result of multiple regression analysis shows that females which had more eggs in their bursa copulatrix lived longer. It is most likely that females consume eggs in the bursa copulatrix and use them to survive, that is, they re-allocate resources from reproduction to survival. There are two pieces of indirect evidence to support our hypothesis for *I. rotundata*. First, most of the eggs in the bursa copulatrix were highly degenerated. We could see many empty eggs or fragmented chorions at the bottom of the bursa, whereas some spheroid shaped eggs were observed near the ductus bursa. These suggest that egg contents were digested and resorbed during retention in the bursa copulatrix. The fact that a spheroid egg was in the ductus seminalis of a female suggests that eggs were transferred from the ovary to the bursa copulatrix via the ductus seminalis. Second, it is reported that many lepidopteran females can consume male spermatophores in their bursa copulatrix as nutrition for their eggs and/or themselves (Boggs & Gilbert 1979, Boggs 1981). In *I. rotundata*, no distinct spermatophores were detected in the bursa copulatrix of the laboratory females. It is possible that not only spermatophores but chorionated eggs are also degenerated in the bursa.

Bell and Bohm (1975) listed many factors promoting oosorption. For example, the restriction of the ovipositional site sometimes increases resorption of eggs. In our experiment, each female was restrained in a small plastic case with a leaf of the host plant. These unnatural conditions might inhibit their oviposition, although they laid eggs readily on the leaf or the wall of the case.

In some insects oocytes are quickly resorbed in the absence of mating. *Illiberis rotundata* females usually mate repeatedly under field conditions (CK unpublished data). In our experiment, however, females were allowed to mate only once. When females are prevented from mating, they may consume some of their eggs in order to live longer and possibly achieve additional matings. Through multiple matings, these females might gain additional nutritional and/or genetic benefits (Arnqvist & Nilsson 2000, Jennions & Petrie 2000).

Resorption can occur in Lepidoptera in response to qualitative or quantitative nutrient deficiencies (Dunlap-Pianka et al. 1977, Boggs & Ross 1993). Adults of *I. rotundata* take only water, and thus no additional nutrients from food are available for survival. Nevertheless they can live for relatively long periods, sometimes more than three weeks. Egg resorption in this species seems to be an effective system for obtaining additional nutrients at the expense of reproduction.

Wild females also had collapsed eggs or degenerated chorions in their bursa copulatrix, but the number of these eggs and chorions was very low. Two reasons for this are to be considered: first, the age of the wild females is uncertain and they may have been dissected at a younger age than the laboratory females, which were dissected after living out their lives. If there is a positive correlation between the number of eggs in bursa copulatrix and female age, younger wild females would have less eggs in the bursa than older laboratory females. Second, wild females may have copulated repeatedly until the point of collection, while the laboratory females mated only once. If males provide nutritional investment to females during copulation, mating frequency will have an effect on egg resorption by females.

Why, then, do *I. rotundata* females resorb eggs in their bursa copulatrix not in ovarioles like other insects? One possible reason could be to eliminate remains after egg resorption. If resorption of chorionated eggs occurs in ovarioles, the remains of resorbed eggs, such as chorions, should be eliminated to facilitate the passage of the following eggs. Some wasps oviposit empty chorions to solve this problem (see Bell & Bohm 1975). Disposal of the remains in the bursa copulatrix seems to be less costly than in ovarioles, because remains can be left in the bursa copulatrix. But it is still unknown why they resorb chorionated eggs.

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## STUDIES IN THE GENUS *HYLEPHILA* BILLBERG, II. THE *BOULLETI* SPECIES GROUP (HESPERIIDAE: HESPERIINAE)

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**ABSTRACT.** This is the second of three papers on the genus *Hylephila* Billberg (1820). The first paper introduced the genus and, emphasizing male and female genitalia, defined four species groups, two of which, the *ignorans* and the *venusta* groups, were treated in detail. The present treatment keys adults; illustrates adults, stigma pockets (male), and genitalia (male and female), and maps the known distribution of the species of the *boulleti* group, seven of which are described as new. Although specimens (especially females) are woefully scant, their characters seem to suggest two subgroups with five known species each. Subgroup I has *H. herrerae*, new species, *H. pseudoherrerae*, new species, *H. pallisteri*, new species, *H. blancasi*, new species, and *H. tentativa*, new species. Subgroup II comprises *H. shapiroei*, new species, *H. galera* Evans, *H. boulleti* (Mabille), *H. rossi*, new species, and *H. peruana* Draudt. Examination of the male and female genitalia is generally necessary to be certain of the identity of a specimen, but wing patterns and some structural characters may permit a “good guess” once familiarity with these skippers is established. Ova of two species were obtained by dissection, and these are described briefly for the first time.

**Additional key words:** South America, oreal (of high mountain), altiplano, Andes, dashed *Phulia* pattern, genitalia (male and female), stigma pockets.

In a previous paper (MacNeill & Herrera 1999) on the genus *Hylephila* Billberg (1820), we introduced the genus, emphasized the importance of male and female genitalia, and reviewed earlier attempts to illustrate these. We recognized, defined, and provided a superficial key to four species groups. We mapped three of these groups which are principally Andean, and treated two of them, the *ignorans* group and the *venusta* group, in detail. We also discussed and figured *Linka lina* (Plötz 1883) owing to confusion about its relationship to some high altitude species of *Hylephila*, especially the *boulleti* group (Shapiro 1994:44, 45), which is treated here in detail. Techniques, methods, and materials—as well as terminology—used in that study also apply in the present paper. A third paper (MacNeill in prep.) will treat the remainder of the genus, the *phyleus* group.

Specimens were examined from several institutions listed below, abbreviations are as follows throughout the text and figure legends:

AME: Allyn Museum of Entomology, Florida Museum of Natural History, Sarasota, Florida.

AMNH: The American Museum of Natural History, New York, New York.

BMNH: The Natural History Museum, London, England.

CAS: California Academy of Sciences, San Francisco, California.

CMNH: Carnegie Museum of Natural History, Pittsburgh, Pennsylvania.

IEUM: Instituto de Entomología, Universidad Metropolitana de Ciencias de la Educación, Santiago, Chile.

IML: Instituto de Zoología, Fundación Miguel Lillo, San Miguel de Tucumán, Argentina.

HNHM: Hungarian Natural History Museum, Budapest, Hungary.

LACM: The Natural History Museum of Los Angeles County, Los Angeles, California.

MUSM: Museo Nacional de Historia Natural, Universidad Mayor de San Marcos, Lima, Perú.

UCD: Bohart Museum of Entomology, University of California, Davis, California.

UFPC: Departamento de Zoologia, Universidade Federal do Paraná, Curitiba, Brasil.

USNM: National Museum of Natural History, Smithsonian Institution, Washington, D.C..

### THE *BOULLETI* GROUP

The ten species of the *boulleti* group all look very much alike superficially. It is usually necessary to dissect the genitalia to identify a specimen. These are small to medium-sized skippers (forewing length 8.5 mm–15 mm). The body is blackish, but the black tegulae are contrastingly and broadly edged with pale yellow or white. On both surfaces of the secondaries (Figs. 32–57) there is a well-defined ray in the cell (at least distally) and through spaces M1–M3. Bold black spots are characteristic on the ventral surface basally, postmedially, and marginally, where they appear to be defined or cut by white or pale veins. This gives the group an appearance when at rest that Shapiro (1985:8–10) has called “the dashed *Phulia* pattern”—a common pattern at rest shared by some high altitude pierids and hesperids of oreol bogs and meadows, and this may well be, as Shapiro suggested, the result of convergence for crypsis at rest. He noted that these swift flying animals are remarkably difficult to find at rest, even when very abundant.

The species of this group occur in the high Andes from central and southern Perú, western Bolivia, and north-eastern Chile into northwestern Argentina and the pre-Andean Nevadas del Aconquija (the Sierras Pampeanas), just west of San Miguel de Tucumán, Ar-



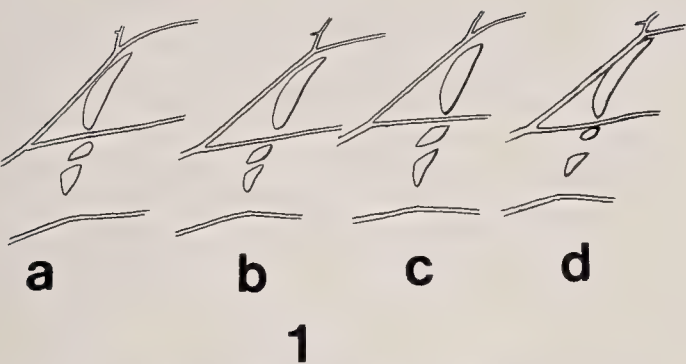


FIG. 1. Diagrams of stigma pockets in males of three species of *Hylephila*. **a**, *H. pallisteri*, new species holotype, PERÚ, Cuzco, Olantaitambo, III-24-47, 9200 ft., C. J. Pallister (genitalic dissection # ♂ 3811-JH), in AMNH. **b**, *H. pallisteri*? PERÚ, Cuzco, Abra Acjanacu, 3600 m, V-17-84, G. Lamas (genitalic dissection # ♂ 6227-CDM), in MUSM. **c**, *H. blancasi*, new species holotype, Santia, donated 1902, P. forte [sic] (genitalic dissection # ♂ 3873-JH), in AMNH. **d**, *H. tentativa*, new species holotype, PERÚ, Ay[acucho], Rio Apacheta, 4200 m, 13°21'S, 74°39'W, I-24-99, G. Lamas, (genitalic dissection # ♂ 6308-CDM), in MUSM.

gentina. All of the species in this group except one are known from Perú, and the exception almost certainly occurs there too.

Because they are found at high elevations where both the weather and access are often limiting, and because of their crypsis (see above), these species of *Hylephila* are not often collected and they remain rare in collections. I have seen more than five specimens of only two of the ten species and females of only five of these (three are single specimens), and I have seen only one male specimen of four of the ten species.

Evans (1955) treated three species of this group as two subspecies of *H. bouletti*, (Mabille 1906), *H. b. bouletti* and *H. b. peruana* Draudt (1923), and one new species, *H. galera* Evans. Seven additional species are described in this paper. Given the general paucity of material, I must admit to some hesitation regarding the possibly presumptive classification presented here for this group of *Hylephila*.

Based upon the male and female genitalia, the species of this group sort rather well into two subgroups. The males of the five species in the first subgroup tend to have the anterior half of the uncus rather rounded in dorsal view and the gnathos is massive and caudoventrally somewhat divergent from the uncus in lateral view (Figs. 12–18); two solitary female specimens lack a detectable sclerotized eighth sternite (Figs. 26, 27). The other subgroup of five species has males with the uncus more or less triangular in dorsal view, with minute lateral serrations caudally, the gnathos not as divergent ventrally from the uncus (Figs. 19–25), females have a distinctly sclerotized eighth sternite.

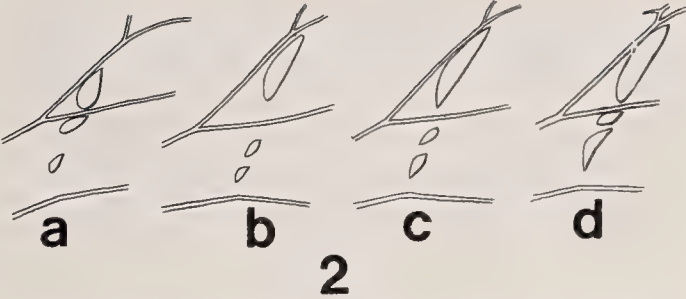


FIG. 2. Diagrams of stigma pockets in males of two species of *Hylephila*. **a**, *H. shapiro*, new species holotype, PERÚ, Junín, vic. Abra Anticona, 4843 m, X-19-83, A. M. Shapiro (genitalic dissection # ♂ 5005-JH), in CAS. **b**, *H. galera* holotype, PERÚ, Junín, Galera Pass, 4800 m, II-?-00, (Simons), in BMNH. **c**, *H. galera*? PERÚ, Junín, Tarma, 3000 m, I-29-72, (genitalic dissection # ♂ 6121-CDM), in LACM. **d**, *H. galera*? PERÚ, Yauli, Corpacancha, 4300 m, 11°22'S, 76°13'W, I-18-97, R. Acero (genitalic dissection # ♂ 6307-CDM), in MUSM.

ARTIFICIAL KEY TO SPECIES

- 1- Male without a stigma ..... 2
- 1'- Male with a stigma ..... 3
- 2- Hindwing above with fulvous of space M1–M3 a short, broad ray, not broadly entering discal cell; below, vannal fuscous area wide, broadly entering space Cu1–2A ..... *H. herrera*, new species
- 2'- Hindwing above with fulvous of space M1–M3 a long ray broadly entering discal cell nearly to base; below, vannal fuscous area narrow, confined to anal cell and space 2A–3A ..... *H. pseudoherrera*, new species
- 3- Male stigma with yellow microandroconial mass conspicuous without magnification, contrasting with other stigmal elements ..... *H. peruana* (Draudt)
- 3'- Male stigma with microandroconial mass inconspicuous without magnification, appearing black to tan and not contrasting with other stigmal elements ..... 4
- 4- Male with upper element of stigma pocket reduced (Figs. 2a, 2b) ..... 5
- 4'- Male with upper element of stigma pocket well developed (Figs. 1, 3) ..... 6
- 5- Very small (FW 8.5 mm). Forewing rather narrow, with upper element of stigma pocket extending distad from vein Cu2 but not nearly reaching origin of vein Cu1 (Fig. 2a); hind tibia with single pair of spurs ..... *H. shapiro*, new species
- 5'- Medium sized (FW 13 mm). Forewing broad, with upper element of stigma pocket extending distad from a point well above vein Cu2 and nearly or quite reaching vein Cu1 (Fig. 2b); hind tibia with two pairs of spurs ... *H. galera* Evans
- 6- Male forewing with microandroconial mass of stigma under magnification appearing black ... *H. pallisteri*, new species
- 6'- Male forewing with microandroconial mass of stigma under magnification appearing gray, tan, or yellowish ..... 7
- 7- Forewing above with broad fuscous border deeply cut by broad fulvous along veins nearly or quite to termen ..... 8
- 7'- Forewing above with fuscous border not deeply cut to termen by fulvous veins, or if deeply cut, narrowly so ..... 10
- 8- Forewing above with pale fulvous postmedian band with inner edge nearly or quite continuously in line with that of subterminal spots. .... *H. blancasi*, new species
- 8'- Forewing above with inner edge of fulvous postmedian band offset at vein M3 from subterminal fulvous spots ..... 9
- 9- Larger insect (FW 13 mm); forewing broad, not produced; fulvous pale ..... *H. galera* Evans
- 9'- Slightly smaller insect (FW 12 mm); forewing somewhat narrow, slightly produced; fulvous warm, almost orange ..... *H. tentativa*, new species



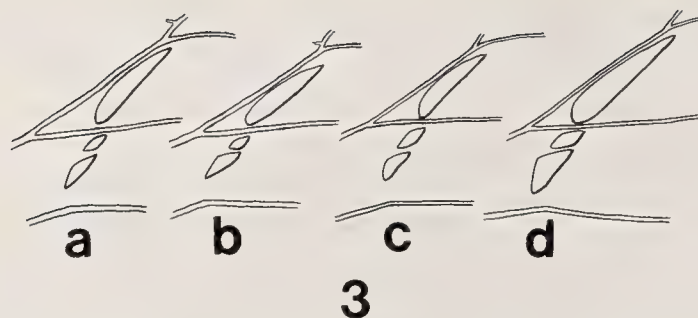


FIG. 3. Diagrams of stigma pockets in males of three species of *Hylephila*. **a**, *H. bouletti*, CHILE, Antofagasta, Tatío, 4360 m, J. Herrera, in CAS. **b**, *H. bouletti*, ARGENTINA, Tucumán, Las Animas, Portozuelo de las Animas, 4540 m, I-26-79, (genitalic dissection # ♂ 5003-JH), in IML. **c**, *H. rossi*, new species holotype, PERÚ, Puno, 10 mi. N. Ayaviri, III-1-51, E. S. Ross & A. E. Michelbacher (genitalic dissection # ♂ 3821-JH), in CAS. **d**, *H. peruana*, PERÚ, Junín, Pachachaca, 4000 m, V-20-79, G. Lamas, (genitalic dissection # ♂ 3871-JH), in MUSM.

- 10- Hindwing above with broad fulvous postmedian macular band extending at least into space Rs-M1, fulvous pale to very pale yellowish ..... *H. bouletti* (Mabille)  
 10'- Hindwing above with narrow fulvous postmedian macular band not extending beyond spaces M1-M3, fulvous dark, nearly orange ..... *H. rossi*, new species

#### SUBGROUP I

#### *Hylephila herrerae* MacNeill, new species

(Figs. 4a, 12, 26, 32, 33, 58)

**Description. Male. Head.** Dorsally scaled black with long, golden vestiture. Palpi and antennae missing. **Body,** collar, and patagia as head, dorsally with orange vestiture. Hind leg with two pairs of spurs. **Wings.** Stubby, rounded. Forewing length 9 mm ( $n = 1$ ). Above stigma absent. Fulvous orange in discal cell (divided by longitudinal fuscous streak), narrowly on costa through area of apical spots, broadly and slightly paler postmedially in space M1-M2, narrowly in space M2-M3, then broadly again in spaces M3-Cu1 and Cu1-Cu2, very narrowly in distal half of space Cu2-2A, and a streak in anal cell; these spots outwardly prolonged along veins. Fringes basally fuscous, outer half whitish with very pale fulvous tint. Below fulvous sullied, much more extensive except fuscous in lower half of space Cu2-2A and all of anal cell. Hindwing above brown with abbreviated fulvous postmedian macular band from veins Rs to Cu2 with spot in space M1-M3 more than thrice width of other spots; an extremely narrow, almost obsolete ray-like streak through lower half of discal cell nearly to postmedian macular band in space M1-M3; fuscous border nearly cut to termen by narrow fulvous along veins. Fringes as on forewing but slightly darker. Below broadly orange-fulvous with paler whitish veins scarcely contrasting with fulvous spaces, and reduced black spots basally in lower costal cell, elongate in mid-space Sc-Rs, basal lower half in discal cell, and round-edged postmedial and border spots in spaces Rs-M1, M3-Cu1, and Cu1-Cu2; vannal fold fuscous and expanding into basal half of space Cu2-2A; veins 2A and 3A scarcely pale. Fringes whitish with fulvous tint. **Genitalia.** Eighth tergite (Fig. 4a) with lateral margin only slightly concave before caudal margin; terminal bristle-sockets scarcely enlarged caudad. Valva (Fig. 12) in lateral view with length of basal margin less than or subequal to one and one-half length of valva. Penis proximally not strongly curved dorsad, its length exceeding length of genitalic capsule but slightly less than twice length of valva; titillators asymmetric, the left large and broadly thorn-like

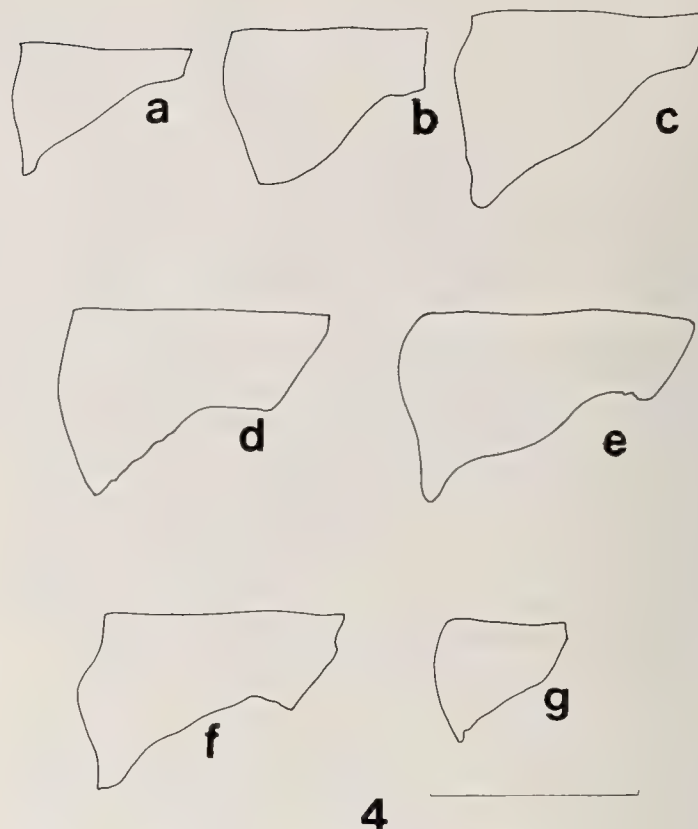


FIG. 4. Eighth tergites in males of five species of *Hylephila* in left lateral view. Scale = 1 mm. **a**, *H. herrerae*, new species holotype, CHILE, Parinacota, "Arica" Cotacotani, 4500 m, II-28-48 (genitalia dissection # ♂ 6117-CDM), in CAS. **b**, *H. pseudohererae*, new species holotype, PERÚ, Ayacucho, Reserva Nac. de Pampas Galeras, 4000 m, II-17-78, J. L. Venero (genitalic dissection # ♂ 3820-JH), in MUSM. **c**, *H. pseudohererae*, new species paratype ♂ same data as holotype except date is I-27-78, (genitalic dissection # ♂ 6311-CDM), in MUSM. **d**, *H. pallisteri*, new species holotype, same specimen as in Fig. 1a. **e**, *H. pallisteri*, same specimen as in Fig. 1b. **f**, *H. tentativa*, new species holotype, same specimen as in Fig. 1d. **g**, *H. shapiroei*, new species holotype, same specimen as in Fig. 2a.

and sclerotically strapped to penis, the right narrowly thorn-like and not sclerotically strapped to penis; cornuti asymmetric, the proximal large and bidentate, the distal evidently fragmented into two subequal, slender, unidentate thorns. Juxta with ventral caudal clefts about one-half length of juxta; separated median floor not nearly reaching caudal margin of juxta. Uncus in dorsal view somewhat rounded cephalad, gradually emarginate to pectines caudad; caudal cleft scarcely exceeding pectines cephalad; pectines minute, not anteriorly rounded, each half broader than long, clearly arched in lateral view, the tines in dorsal view obscure, many, and scarcely separated. Gnathos in lateral view dorsally distinctly sclerotized, not exceeding pectines caudad, and greatly divergent ventrally from uncus.

**Female. Head and body** as male. Antennal club large, about three-fourths length of shaft, club posteriorly black with scattered golden scales, anteriorly and below buffy, golden above; nudum brown, less than one-fourth length of club, shaft buff. Palpi with second segment shaggy with mixed orange and black, long, hair-like scales exceeding length of third segment which is scaled black and orange. Eyelash greater than one-half eye diameter, orange, and black scaled. Collar and patagia dorsally orange scaled with emergent, scattered, long, hair-like, black scales. **Wings.** Somewhat more produced and apically pointed than male (Fig. 33). Forewing length 10 mm ( $n = 1$ ). Above as male but fuscous markings more extensive



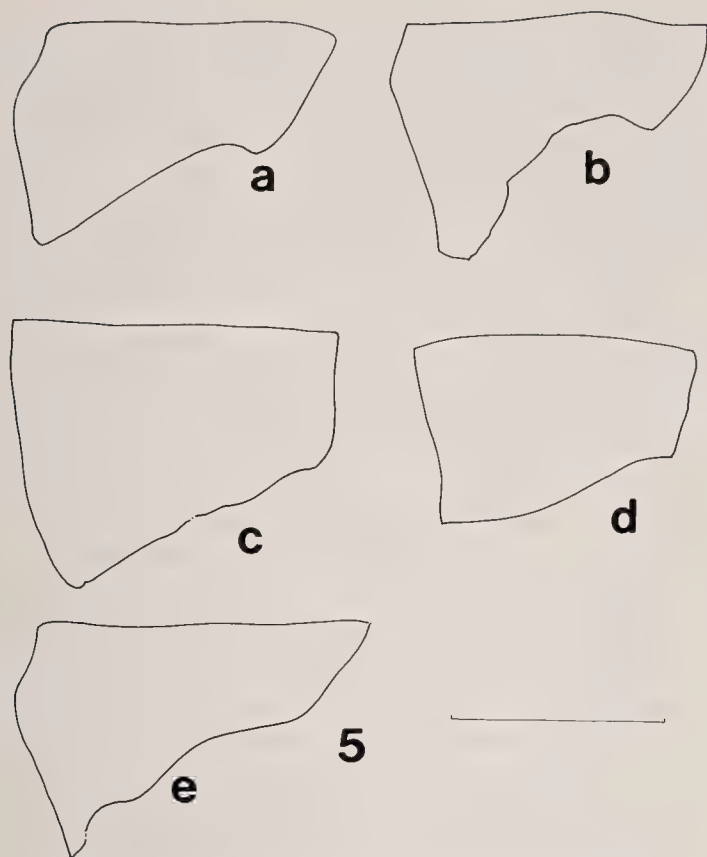


FIG. 5. Eighth tergites in males of three species of *Hylephila* in left lateral view. Scale = 1 mm. **a**, *H. galera*?, same specimen as in Fig. 2c. **b**, *H. galera*?, same specimen as in Fig. 2d. **c**, *H. bouletti*, CHILE, Antofagasta, Salar Aguas Calientes, 4000 m, II-27-60, L. Peña (genitalic dissection # ♂ 6125-CDM), in AME. **d**, *H. bouletti*, ARGENTINA, Catamarca, Quebrada de los Cazadores, grupo austral Nevadas del Aconquija, 5400–4800 m, XI-23-48, M. Lamb (genitalic dissection # ♂ 6213-CDM), in CAS. **e**, *H. peruana*, same specimen as in Fig. 3d.

in costal cell; below as male but fuscous marginal wedge-shaped spots more prominent from space M1–M2 to space R4–R5 where otherwise inconspicuous pale veins are conspicuous to termen. Hindwing above as male, fulvous increased discally in lower distal half of discal cell continuing ray-like through spaces M1–M3 and in lower half of spaces Cu2–2A and 2A–3A; below as male but with broadly scaled white veins more prominent, fuscous spots reduced. Fringes whitish with fulvous tint vannally. **Genitalia.** (Fig. 26). Eighth sternite not sclerotized. Apophysis anterioris in lateral view scarcely produced cephalad of junction with lamella postvaginalis. Lamella postvaginalis in ventral view broadly medially united, each half produced ventro-cephalad forming an anterior bulge not nipple-like, medially produced ventrad into a narrow, double-folded, U-shaped flange just caudad of the mostly membranous antrum. Antrum caudodorsally weakly and irregularly sclerotized, anterodorsally weakly sclerotized immediately caudad of ductal constriction. Ductus bursae weakly sclerotized laterally, ventrally mostly membranous, left lateral pocket not produced.

**Types.** Holotype ♂, CHILE, “Arica,” Parinacota, Cotacotani, 4500 m, II-28-48 (genitalic dissection # ♂ 6117-CDM), in CAS. Paratype. 1 ♀, same data as holotype but additional determination label by K. J. Hayward as *Hylephila phylaeus basistrigata* Eaton. (genitalic dissection # ♀ 6118-CDM), in CAS.

**Etymology.** With considerable pleasure I name this species for my good friend, the late Prof. José Valentín Herrera G., to whom

this paper is dedicated. Pepe Herrera devoted well over four decades to the collection and study of Chilean Lepidoptera. He was actively involved with this study of *Hylephila* and co-authored our first paper on this genus.

**Diagnosis and discussion.** This species is distinguished by its small size, lack of a stigma in the male, and the broadly darkened vannal area above. It differs from males of *H. pseudoherrerai* in its smaller size, darker wing markings, and in genitalic details of the uncus, pectines, and juxta. The female genitalia most resemble those of *H. tentativa* in the lack of a sclerotized eighth sternite, but the very short apophyses anteriores, and weakly sclerotized, short ductus bursae differ from these structures in *H. tentativa*. The wing borders are not as broadly cut by fulvous along the veins as are those of *H. tentativa*. The species flies in February.

*Hylephila pseudoherrerai* MacNeill,  
new species

(Figs. 4b, 4c, 13, 14, 34, 35, 58)

**Description. Male. Head.** Dorsally dark, black and golden scaling mixed equally, except for pale golden patch over eye behind black eyelash. Antennae with club black posteriorly, anteriorly buff merging to golden above, club about one-half length of shaft, nudum dark brown, about one-fourth length of club. Palpi golden, second segment somewhat shaggy, long, black, hair-like scales restricted to anterolateral angles, third segment dorsally black, scarcely emerging from vestiture of second segment. **Body.** Dorsally black with long, golden, hair-like overscaling, except for pale golden patagia and pale margins of otherwise black tegulae. Hind tibia with two pairs of spurs. **Wings.** Narrow and rounded to somewhat rounded at tornus. Forewing length, holotype 11 mm, one paratype 12 mm. Above stigma absent. Fulvous rich to cold orange costad of discal cell merging with apical spots (but sullied basad), in discal cell (where divided by broad, blackish fuscous streak from base to end cell where connected broadly to elongate black spot between end cell and subterminal spots), and below cell in base of space Cu1–Cu2, in subterminal spots and in postmedian band from spaces M3–Cu1 to Cu2–2A, where sullied, and in most of cell where also sullied. Fuscous border broad, only slightly cut by fulvous veins. Fringes brownish, at tornus sullied fulvous. Below costad, apically on veins, and distally on fringes, whitish. Hindwings above with fulvous somewhat restricted to a ray in distal half of cell through spaces M1–M3 to broad, fuscous border, in cell Cu2–2A from near base nearly or quite to margin, and narrowly as part of the postmedian macular band in spaces Cu1–Cu2 and M3–Cu1, and scarcely evident in space Rs–M1; fuscous border broad, scarcely cut by fulvous veins. Fringes pale fulvous to vannally fulvous and apically fuscous. Below, extensively pale fulvous with contrasting white veins Sc to Cu2; black spots basally in costal cell, discal cell, and ray-like from base to margin in space 2A–3A and anal cell, postmedially near base of spaces Rs–M1, M3–Cu1, and Cu1–Cu2, indistinctly and ray-like in Sc+R1–Rs, marginally in spaces Rs–M1, M3–Cu1, and Cu1–Cu2. Fringes slightly paler than above with a slight violet tint. **Genitalia.** Eighth tergite (Figs. 4b, 4c) lateral margins slightly emarginate before caudal margin; terminal bristle-sockets slightly enlarged before caudal margin. Valva (Figs. 13, 14) narrow, in lateral view with length of basal margin more than (or slightly less than) one and one-



half depth of valva. Penis strongly curved dorsad anteriorly (or straight), its length exceeding length of capsule and subequal to twice length of valva; titillators sclerotically strapped to penis, slightly asymmetric, the left more robust than the right, thorn-like with its point (more or less) angled ninety degrees from its base, cornuti bidentate, slightly asymmetric. Juxta with ventrocaudal clefts about one-half length of juxta, the separated median floor nearly reaching caudal margin of juxta. Uncus in dorsal view greatly expanded and rounded cephalad, then abruptly emarginate caudad, or smoothly tapered, to pectines; caudal cleft distinctly exceeding pectines cephalad; pectines small, each half broader than long, not anteriorly rounded, the tines conspicuous, few; in lateral view somewhat arched. Gnathos in lateral view dorsally distinctly sclerotized, not to slightly exceeding pectines caudad, and greatly to somewhat divergent ventrad from uncus.

**Female.** Unknown.

**Type.** Holotype ♂, PERÚ, Ayacucho, Reserva Nac[ional] de Pampas Galeras, 4000 m, 17-II-78, J. L. Venero (genitalic dissection # ♂ 3820-JH), in the Museo Nacional de Historia Natural, Perú (MUSM). Paratypes. 1 ♂, same locality and collector as holotype, but 27-I-78, (genitalic dissection # ♂ 6311-CDM); 1 ♂, same locality but date 21-IV-74 and G. Lamas, collector (genitalic dissection # ♂ 3736-JH). Paratypes will be placed in MUSM and CAS.

**Etymology.** This species, while small and without a male stigma, is not the same species as *H. herrerae*.

**Diagnosis and discussion.** The holotype has narrower wings and is more orange than one paratype. The latter is larger, paler, and looks very much like a female of *H. bouletti*, which I thought it was until I dissected it. The genitalia are slightly different in the type and one paratype; those of the paratype (# ♂ 6311-CDM) somewhat resemble those of *H. herrerae*, but the locality data and the contrasting white veins on the hindwing venter suggest that all three specimens are samples of the same population. *Hylephila herrerae* is smaller with broader fuscous markings above and lacks contrasting white veins below, and the genitalia of *H. herrerae* differ in the narrower uncus, smaller pectines with inconspicuous tines, and a shorter juxtal median floor. The species has been collected in January, February, and April.

### *Hylephila pallisteri* MacNeill, new species

(Figs. 1a, 1b, 4d, 4e, 15, 16, 36, 37, 58)

**Description. Male. Head.** Dorsally scaled orange fulvous; eye-lash black with scattered orange hairs. Antennae with club anteriorly and above orange, merging to white below, posteriorly black; nudum orange shading to brown on apiculus; shaft length more than twice length of club. Palpi with third segment protruding above vestiture of second segment; second segment vestiture black above and on distal third below, lateral scales orange blending to white, hair-like scales anteriorly orange, but at anterolateral angles black. **Body,** patagia, and collar as head, dorsally with orange vestiture. Hind legs with two pairs of spurs. **Wings.** Broad. Forewing length 11 mm (second specimen 14 mm) (n = 2). Above stigma present, slender; microandroconial mass black, inconspicuous amid other black stigmal elements; post-stigmal patch conspicuous, broad. Orange fulvous discally greatly reduced by broad fuscous border scalloped along veins, but broadly orange in costal and subcostal spaces from base

nearly to subapical fulvous spots, and through entire discal cell except where divided longitudinally by slender fuscous streak; narrow subterminal spots distinctly offset from only slightly broader postmedian macular band. Fringes broadly fuscous, terminally pale fulvous. Below, stigma pocket upper element extends well beyond origin of vein Cu1 and diverges from discal cell about equidistant from origins of veins Cu1 and Cu2, lower elements large (Figs. 1a, 1b). Orange fulvous as above but broader discally and more restricted basad by fuscous in spaces Sc-R, basal half of Cu2-2A, discal cell, and entire anal cell; costa white and veins R3 to M2 distally white, black bar end discal cell and fuscous spots postmedially in spaces M1-M2, M2-M3, and M3-Cu1 more or less heavily overscaled with fulvous, and distal to stigma pocket in spaces Cu1-Cu2 and Cu2-2a. Hindwing above fuscous, fulvous restricted to streak through lower half of discal cell and a very narrow postmedian macular band Cu2-2A to crescent in Rs-M1, and weakly along vein 2A to termen, fringes as forewing but more orange. Below fulvous with veins (except M2) from Cu1 to Sc strongly contrasting white; rounded black spots basally in costal and discal cells, postmedially and marginally in spaces Sc-Rs, Rs-M1, M3-Cu1, Cu1-Cu2, and discally in upper half of discal cell; space Cu2-2A fulvous from base to termen, vein 3A distal two-thirds fulvous; fringes more orange than above. **Genitalia.** Eighth tergite with lateral margin broadly emarginate before caudal margin (Figs. 4d, 4e), terminal bristle-sockets enlarged just before caudal margin. Valva (Figs. 15, 16) in lateral view narrow, basal margin not strongly convex, its length subequal to one and one-half times depth of valva, dorsal margin not greatly concave to caudal beak; in caudal view lower half of horizontal cleft narrow, scarcely one-half width of knobbed upper half. Penis proximally slightly curved dorsad, its length exceeding length of genitalic capsule and about twice length of valva; titillators asymmetric, the left large, broadly thorn-like, and sclerotically strapped to penis, the right much reduced, narrowly thorn-like, and obscurely strapped to penis; cornuti bidentate, asymmetric, the proximal basally much elongate, the distal not elongate. Juxta with ventrocaudal clefts short, about one-fourth length of juxta; separated median floor reaching caudal margin of juxta. Uncus in dorsal view distinctly round cephalad, abruptly tapered to caudal pectines; the caudal cleft not exceeding pectines cephalad; pectines small, each half longer than broad, anteriorly and posteriorly rounded, the tines few, conspicuous, in lateral view scarcely arched. Gnathos in lateral view dorsally clearly sclerotized, not exceeding pectines caudad, and greatly divergent ventrad from uncus.

**Female.** Unknown.

**Type.** Holotype ♂, PERÚ, Cuzco, Ollantaitambo, III-24-47, 9200 ft., C. J. Pallister (genitalic dissection # ♂ 3811-JH), in AMNH.

**Etymology.** This species is named for the collector of the holotype, C. J. Pallister.

**Diagnosis and discussion.** Two additional specimens have been seen. One, a male from Yungas (or LaPaz) Bolivia, 1000 m, ex H. Rolle, 1902, R. Oberthur Coll'n. (genitalic dissection # ♂ 3815-JH) was prematurely returned to the BMNH identified as *H. bouletti*, but was noted as having identical genitalia to specimen # ♂ 3811-JH (the holotype of *H. pallisteri*). I have not examined this specimen in detail.

A more recent specimen (Figs. 1b, 4e, 16, 37, 58) from PERÚ, Cuzco, Abra Acjanacu, 3600 m. 17-V-84, ♂. Lamas (genitalic dissection # ♂ 6227-CDM), in MUSM, seems to be this species; but it differs in sev-



eral particulars from the holotype: It is much larger with a forewing length of 14 mm. The antennal club is longer so the shaft is about twice the length of the club. The third palpal segment is ventrally entirely fulvous, not black on the distal third. On the wings above the post-stigmal patch is not as broad as in the holotype, and below the stigmal pockets are more robust. The markings are quite similar; but on the hindwing venter there is an extra elongate postmedian black spot in the upper fourth of space M1–M3, and vein M2 is apparent and whitened. The genitalia also differ in that the valva is a bit narrower with the length of the basal margin more than one and one-half times the depth, and the lower one-half of the horizontal beak cleft in caudal view is nearly as wide as the upper half. The penis is not as strongly bent dorsad proximally, and the discal cornutus is unidentate. The juxta has the ventrocaudal clefts long, about half the length of the juxta. The uncus in dorsal view has the lateral margin more abruptly emarginate caudad before the pectines and the caudal cleft distinctly exceeding the pectines cephalad. The pectines are small with each half scarcely longer than broad, and anteriorly as well as posteriorly scarcely rounded, and the tines are numerous and inconspicuous. The gnathos in lateral view is only somewhat divergent ventrally from the uncus. These characters suggest that perhaps this specimen represents a closely related species.

The two specimens are distinctive in the orange fulvous above with broad borders, the very black stigmal elements including the microandroconial mass, and the dark fuscous, orange fulvous, and contrasting white veins below. The specimens were collected in March and May.

### *Hylephila blancasi* MacNeill, new species

(Figs. 1c, 6, 9, 17, 38, 39, 58)

**Description. Male. Head.** Dorsally pale fulvous. Antennal club anteriorly and above orange fading to pale buff below, posteriorly black; nudum pale brown; shaft slightly longer than twice length of club. Palpi shaggy, pale fulvous, second segment front has hair-like scales pale, anterolateral angles black, laterally scales pale, not hair-like, third segment dorsally black, scarcely emerging from vestiture of second segment. **Body** dorsally black with long, pale, golden, hair-like overscaling, except for golden patagia and margins of otherwise black tegulae. Hind tibiae with two pairs of spurs. **Wings.** Forewing produced, length 12 mm (range 11–13 mm) ( $n = 5$ ). Above stigma present; microandroconial mass dark gray, inconspicuous; post-stigmal patch narrow. Fulvous extensive from costa through discal cell, basally sullied, a short black streak dividing distal half and an oblique black line at end of discal cell; fuscous border divided to termen by fulvous along veins; inner edge of subterminal fulvous spots usually in line with inner edge of postmedian macular band. Below, stigma pocket upper element extends just beyond origin of vein Cu1, diverges from discal cell cubitus vein much nearer to origin of vein Cu1 than Cu2, and reaches vein Cu2, lower ele-

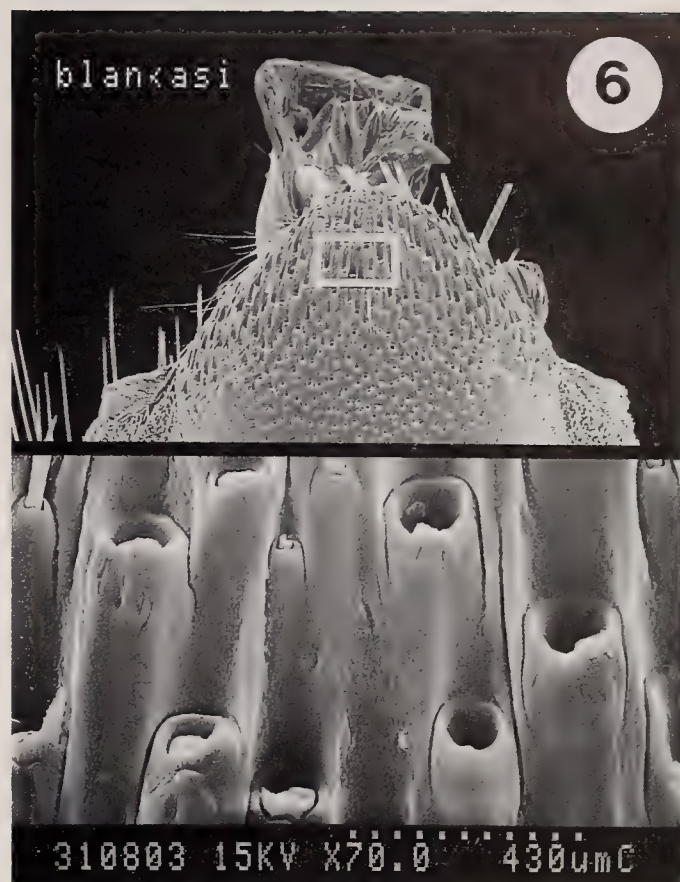


FIG. 6. SEM image of male eighth tergite (dorsal aspect) of *H. blancasi*, new species paratype (descaled to show caudal array of bristle-sockets at 70X, with inset enlarged below). [PERÚ, Lima] cerca (sic) Canta, 4700 m, XII-13-47, Coll. Blancas (SEM #9, 23-CDM), in CAS.

ments very large (Fig. 1c); costa whitened (gray where worn) and veins Rs to M3 buff distally (clearly white in two paratypes); extensive fulvous pale, obscuring subapical fulvous spots; discal cell, costal cell, and space Sc–R all black at base, as is basal half of space Cu2–2A and all of anal cell; marginal fuscous spots isolated by pale fulvous along veins to termen, that in space M1–M2 nearly obsolete; diagonal black bar at end of discal cell, fuscous postmedian spots in spaces Cu1–Cu2, M1–M2, and M2–M3, the latter two heavily overscaled fulvous. Hindwings above with costal cell and space Sc–Rs fuscous, fuscous border nearly or quite divided to termen by fulvous extensions along veins, fulvous of space M1–M3 a ray-like extension well into discal cell, fuscous basal half of postmedian spaces Cu2–2A, Cu1–Cu2, and discal cell all heavily overscaled with fulvous; postmedian fulvous spot in space Rs–M1 an angular crescent, the upper half twice as wide as lower half. Below pale fulvous restricted by white scaling very broadly along side of veins Rs to Cu2, but scales of veins M3, Cu1, and Cu2 light brownish, contrasting with whitish to pale fulvous intervein spaces (one paratype has thin white streak mid fulvous of space Cu2–2A), space 2A–3A and anal cell wholly fuscous, vein 1A a thin fulvous streak, basal and post-medial black spots edged or partly overscaled by cupreous scales or hairs. Fringes dusky, vannally pale orange. One paratype (# ♂ 3819-JH) has fulvous extensive and dark markings much reduced like *H. galera* and forewing subterminal fulvous spots in spaces M1–M2 and M2–M3 slightly offset from postmedian band spots in spaces M3–Cu2 to Cu2–2A owing to fulvous expanded basad in M3–Cu1. Another paratype (SEM # ♂ 23-CDM) has more extensive dark



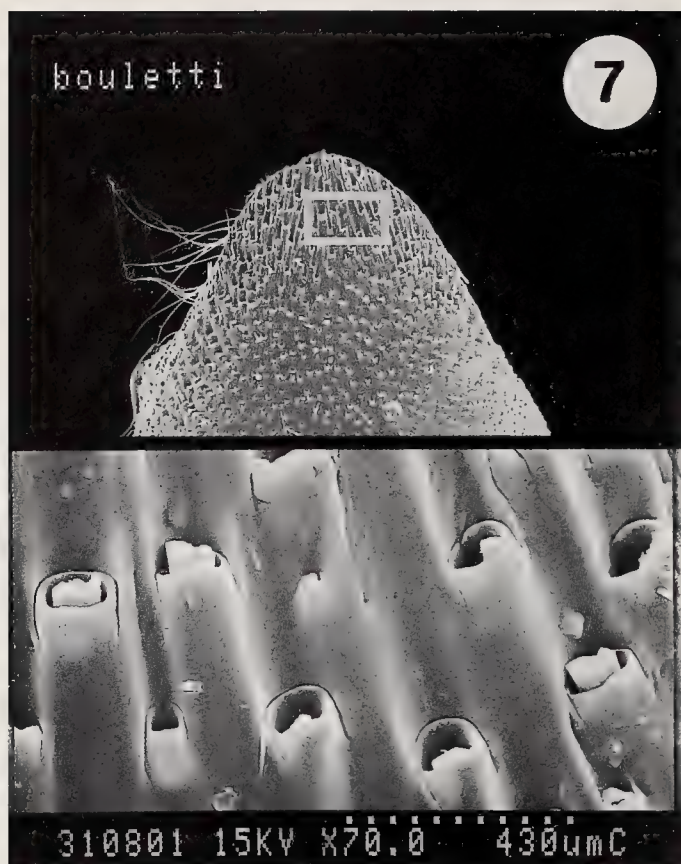


FIG. 7. SEM image of male eighth tergite (dorsal aspect) of *H. bouletti* (descaled to show caudal array of bristle-sockets at 70 $\times$  with inset enlarged below). CHILE, Parinacota, nr. base Vol. Guallatire, 4500 m, XI-21-94, A. M. Shapiro (SEM #7-CDM), in CAS.

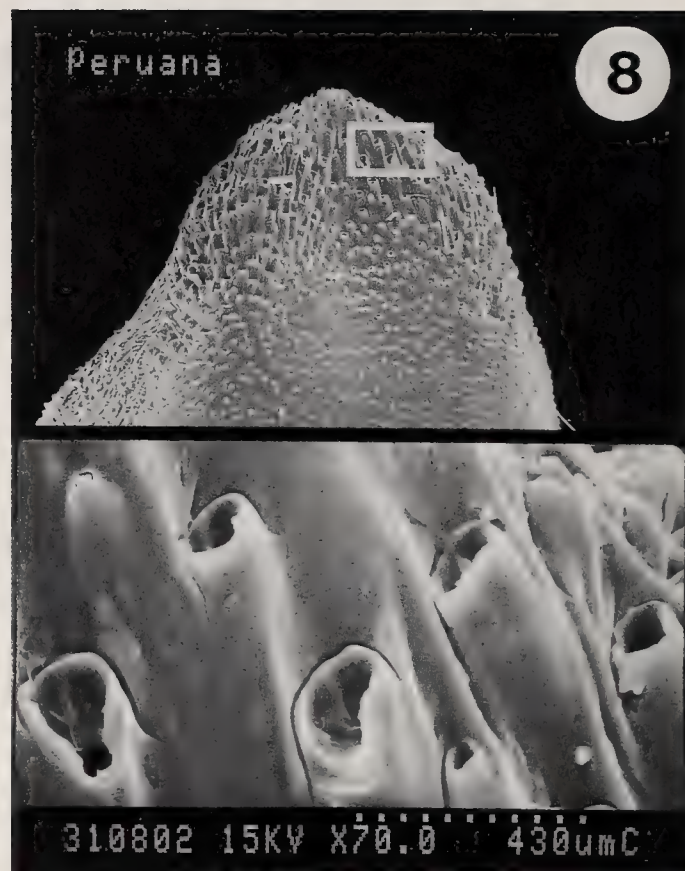


FIG. 8. SEM image of male eighth tergite (dorsal aspect) of *H. peruana* (descaled to show caudal array of bristle-sockets at 70 $\times$ , with inset enlarged below). PERÚ, Junín, Pachachaca, 4000 m, V-20-79, G. Lamas (SEM #8-CDM), in MUSM.

markings above so the fulvous subterminal spots are not only offset but completely separated from the fulvous postmedian band. **Genitalia.** Eighth tergite with lateral margin distinctly emarginate before caudal margin, terminal bristle-sockets conspicuously enlarged caudad, more or less rounded in cross section (Fig. 6). Valva (Fig. 17) in lateral view broad, with ventral margin strongly convex but distad abruptly concave to a prominent beak; dorsal margin basally abruptly concave to the caudal beak, length basal margin slightly greater than one and one-half times depth of valva. Penis proximally scarcely (or not) curved dorsad, its length exceeding length of genital capsule and greater than twice length of valva; titillators nearly symmetric, broadly based, thorn-like, and sclerotically strapped to penis, the right slightly reduced; cornuti asymmetric, bidentate, one much more broadly elongate. Juxta with ventral caudal clefts long, about one-half length of juxta, separated median floor scarcely reaching caudal margin of juxta. Uncus in dorsal view with distinctly rounded cephalic and lateral margins, then emarginate and abruptly tapered, without serrations, to caudal pectines, the caudal cleft not (or slightly) exceeding pectines cephalad; pectines minute (Fig. 9), each half about as long as broad, anteriorly and posteriorly not, to somewhat, rounded, the tines many, inconspicuous, somewhat arched in lateral view. Gnathos massive in lateral view, dorsally distinctly sclerotized, not exceeding pectines caudad, and greatly divergent ventrally from uncus.

**Female.** Unknown.

**Type.** Holotype  $\sigma$ , PERÚ, Santa, donated 1902, P. forte [sic] (genitalia dissection #  $\sigma$  3873-JH), in AMNH. Paratypes. 1  $\sigma$ , [PERÚ, Lima] cerca Canta, 4700 m, 13-XII-47, Coll. Blancas (SEM #  $\sigma$  9, 23-CDM); 1  $\sigma$ , [PERÚ, Junín] entre La Oroya Tilarnioc, 10-I-49, Coll. Blancas (genitalia dissection #  $\sigma$  3819-JH); 1  $\sigma$ , [PERÚ]

#22694, E. E. Olcott (genitalia dissection #  $\sigma$  3874-JH); 1  $\sigma$ , [PERÚ] illegible locality, Huanuco, Holland Collection (genitalia dissection #  $\sigma$  6280-CDM). Paratypes will be placed in the following collections: AMNH, CAS, CMNH.

**Etymology.** This species is named for the collector of the first two specimens I saw of this species. The holotype was selected because it is in better condition.

**Diagnosis and discussion.** *Hylephila blancasi* has superficial markings similar to those of *H. galera*. One paratype (genitalia dissection #  $\sigma$  3819-JH) is very like the latter with pale fulvous extensive on the dorsal forewing, the dark markings much reduced, and the forewing subterminal fulvous spots in spaces M1-M2 and M2-M3 slightly offset from the postmedian band of fulvous spots from M3-Cu1 to Cu2-2A, owing to the fulvous expanded basad in space M3-Cu1. *Hylephila galera*, however, has much broader wings and genitally belongs with subgroup II. Another paratype of *H. blancasi* (SEM #  $\sigma$  9, 23-CDM) has the dorsal forewing subterminal spots reduced and completely separated from a narrowed postmedian band by a combination of a distally expanded subapical fuscos spot and a greatly broadened marginal border. *Hylephila blancasi* flies in December and January.

The following species, *H. tentativa*, is remarkably similar to *H. blancasi*; but the fulvous of the wing



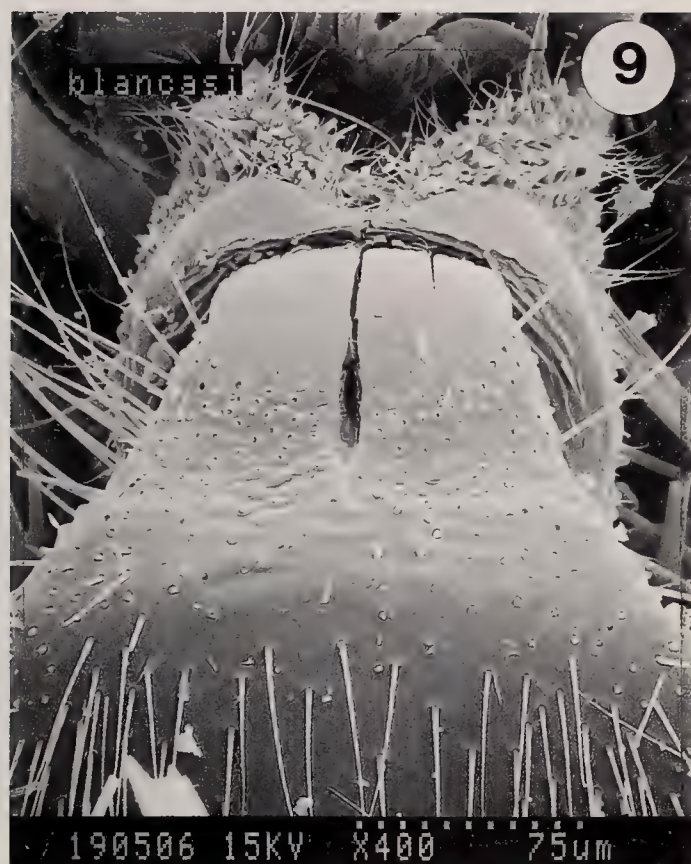


FIG. 9. SEM image of caudal tip of uncus (dorsal aspect) of male *H. blancasi* showing pectines at 400 $\times$ . Same specimen as Fig. 6 (SEM #9, 23-CDM), in CAS.



FIG. 10. SEM image of caudal tip of uncus (dorsal aspect) of male *H. bouletti* showing pectines at 400 $\times$ . CHILE, Parinacota, Reserv. Nac. Salar de Surire, no. shore, 4250 m, XI-22-94, A. M. Shapiro (SEM #22-CDM), in CAS.

above is much more orange on *H. tentativa*, the male stigma is less well developed, and the genitalia are somewhat different. The valva of *H. blancasi* is much broader, the titillators are more robust and the cornuti distinctly bidentate, the juxta is less robust, the uncus in dorsal view is anteriorly more rounded and the pectines slightly larger with numerous, inconspicuous tines, and the gnathos is caudally more or less inconspicuous from above than are these structures in *H. tentativa*.

### *Hylephila tentativa* MacNeill, new species

(Figs. 1d, 4f, 18, 27, 40, 41, 58)

**Description. Male. Head.** Dorsally black with mixed golden and black hair-like vestiture. Antennae dorsally black on club, black mixed with white scales on shaft, anteriorly golden on club and shaft fading to buff basally; club less than one-half length of shaft, nudum pale brown; shaft length slightly greater than dorsal width of head. Palpi shaggy; third segment black, slightly protruding anteriorly from vestiture of second segment in dorsal view, in lateral and ventral views scarcely protruding from rich, golden, fulvous, hair-like vestiture of front of second segment. Eyelash length about one-half eye diameter. **Body** dorsally black with sparse golden, hair-like scales. Tegulae black with broad, pale edges. Legs with hind tibiae bearing two pairs of spurs. **Wings.** Somewhat narrow, slightly produced. Forewing length 12 mm ( $n = 1$ ). Above stigma present, evident but not conspicuous; microandroconial mass very narrow, scarcely distinguishable between very abbreviated brush patches,

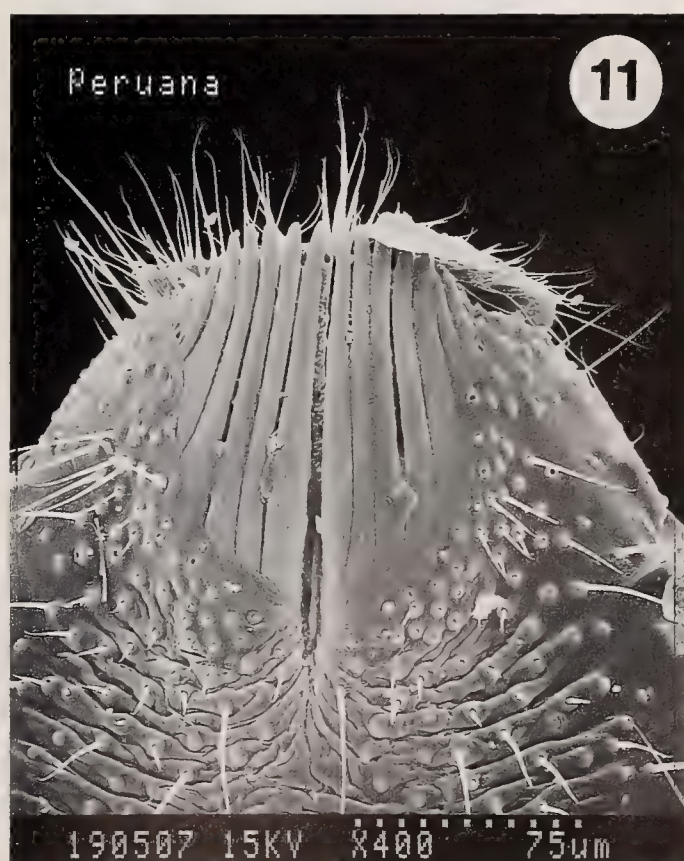
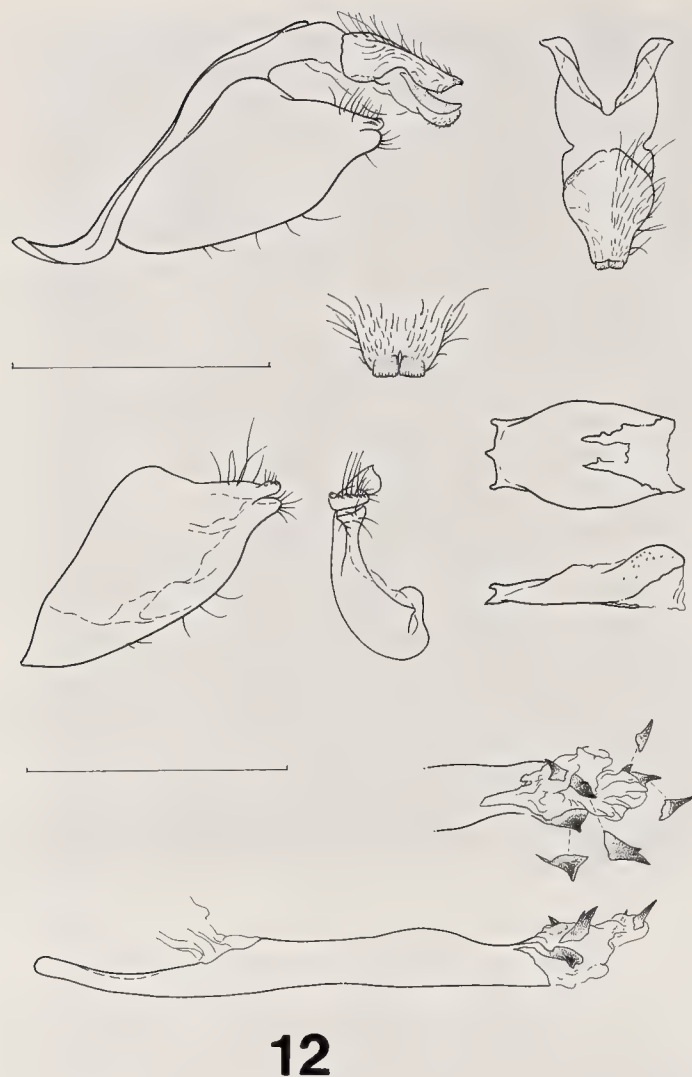


FIG. 11. SEM image of caudal tip of uncus (dorsal aspect) of male *H. peruana* showing pectines at 400 $\times$ . PERÚ, Podocayo, Feb.-May 1925 (SEM #24-CDM), in LACM.

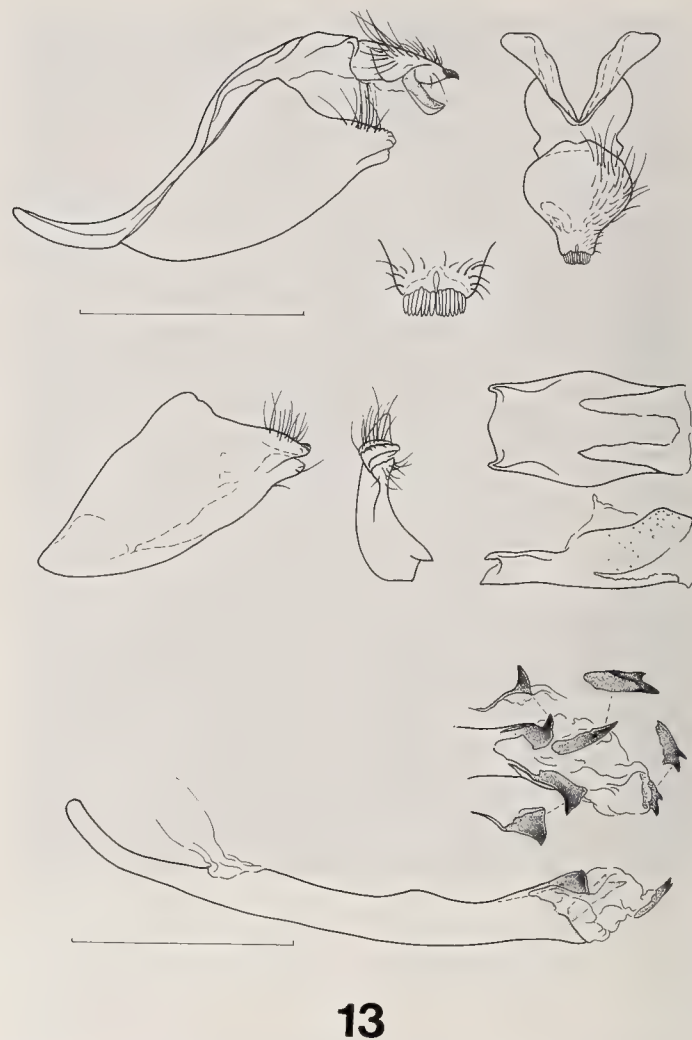




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FIG. 12. Male genitalia of *H. herrerae*, new species holotype. Uncus (lateral and dorsal aspects, dorsal of pectines enlarged), valvae (left outer and caudal aspects, right inner aspect), juxta (left lateral and ventral aspects), penis with vesica everted (left lateral and distal dorsal aspects). Data as Fig. 4a. Scale = 1 mm.

post-stigmal patch narrow but most conspicuous stigmal element. Fulvous warm, ruddy, almost orange, abruptly contrasting with fuscous markings; border cut to termen by fulvous along veins. Inner edge of fulvous subterminal spots not in line with inner edge of post-median macular band. Fringes basally fuscous, terminally buffy orange. Below, rich fulvous more extensive, fuscous markings reduced, veins R5, M1, and M2 whitened as is the costa from base to apex. Stigma pocket with upper element very narrow, its width scarcely twice diameter of adjacent cubitus vein, lower elements reduced, widely separated. Hindwing above with rich fulvous postmedian macular band from spaces R5–M1 to Cu1–Cu2, and fulvous rays from base discal cell to margin in space M1–M3 and near base to margin in Cu2–2A; fuscous border cut to termen by fulvous along veins. Below fulvous somewhat paler but not nearly whitish, fuscous spots broadly separated by fulvous flanking the whitened veins from Rs to Cu2, space Cu2–2A from base to termen all fulvous, a poorly defined, narrow, pale ray from near base to termen along vein 3A in otherwise fuscous vannal area. **Genitalia.** Eighth tergite (Fig. 4f) laterally conspicuously emarginate immediately cephalad of caudal margin; terminal bristle-sockets conspicuously enlarged caudad. Valva (Fig. 18) in lateral view narrow, length basal margin distinctly more than one and one-half times valva depth, dorsal margin some-



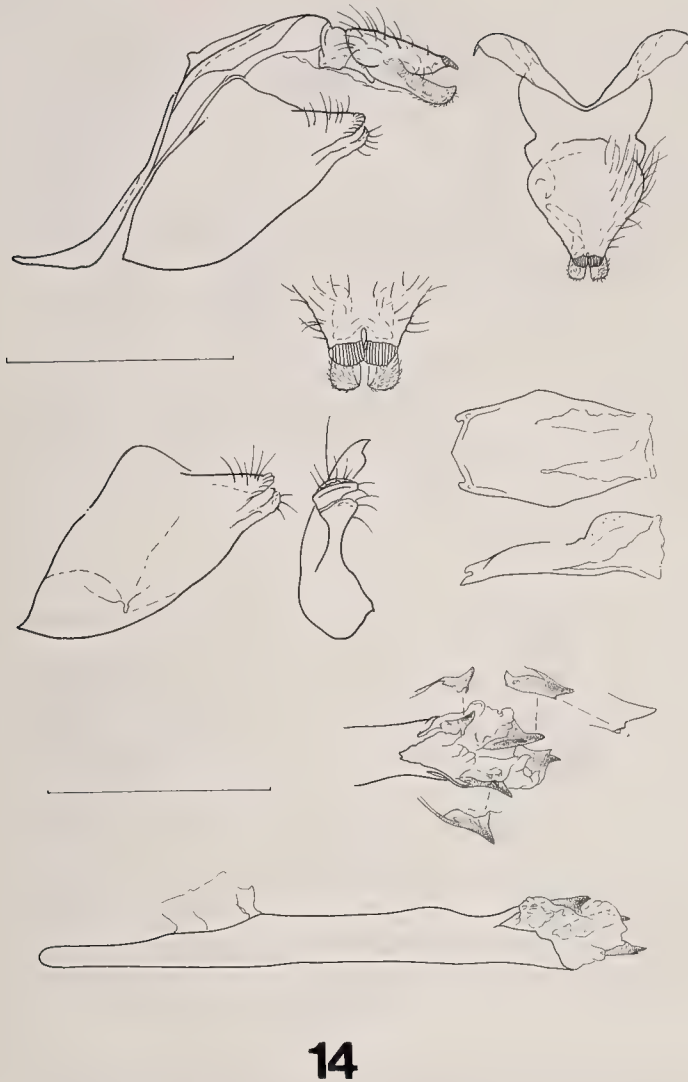
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FIG. 13. Male genitalia of *H. pseudoherrerae*, new species holotype. Uncus (lateral and dorsal aspects, dorsal of pectines enlarged), valvae (left outer and caudal aspects, right inner aspect), juxta (left lateral and ventral aspects), penis with vesica everted (left lateral and distal dorsal aspects). Data as Fig. 4b. Scale = 1 mm.

what concave, caudal beak not prominent. Penis about twice length of valva; titillators sclerotically strapped to penis, slender, thorn-like, asymmetric, the left basally much more massive than the right; cornuti asymmetric, one bidentate and basally massive, the other smaller and minutely tridentate. Juxta with ventral caudal clefts about one-half length of juxta and separated mid-ventral floor nearly reaching caudal margin of juxta. Uncus in dorsal view more or less triangular, cephalic margin somewhat convex, and lateral margins from cephalic lateral angles only slightly sinuate and tapered to pectines, caudal cleft distinctly exceeding the pectines cephalad; pectines minute, not anteriorly rounded, each half longer than broad, the tines few, conspicuous, in lateral view scarcely arched. Gnathos massive, sclerotized, projecting caudad well beyond pectines in dorsal view, divergent from uncus in lateral view.

**Female.** Head and body as male but fulvous paler, cheeks and eye ring white. Antennal club slightly less than one-half length of shaft, club black, posteriorly buffy, anteriorly and below, not checkered on shaft; nudum brown, slightly less than one-half length of club. Palpi second segment shaggy, pale to buffy fulvous, black hair-like scales restricted to anterolateral angle. Eyelash about one-half eye diameter. Patagia dorsally fulvous. **Wings.** Somewhat produced and apically pointed. Forewing length 12.5 mm ( $n = 1$ ). Above as male, fulvous paler, less ruddy, fuscous of discal "false stigma" more



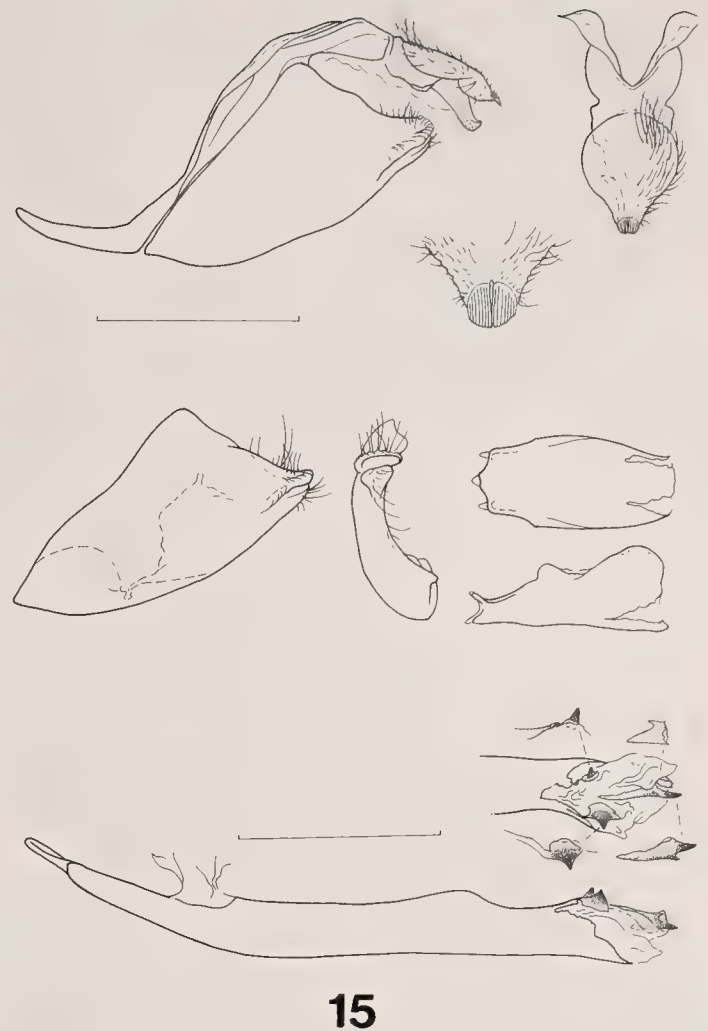


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FIG. 14. Male genitalia of *H. pseudoherrerai*, new species, paratype. Uncus (lateral and dorsal aspects, dorsal of pectines enlarged), valvae (left outer and caudal aspects, right inner aspect), juxta (left lateral and ventral aspects), penis with vesica everted, (left lateral and distal dorsal aspects). Same specimen as in Fig. 4c. Scale = 1 mm.

extensive than male, border sharply cut to termen along veins from M1 to 2A, inner edge of subterminal fulvous spots not in line with inner edge of postmedian band; termen fuscous; fringes basally fuscous, terminally paler except apically. Below pale fulvous as male but veins less whitened. Hindwing above as male but fulvous less ruddy. Below as male but fuscous markings slightly broader; termen fuscous; fringes basally fuscous, terminally buffy. **Genitalia.** (Fig. 27). Eighth sternite not sclerotized. Apophysis anterioris in lateral view produced cephalad of junction with lamella postvaginalis, its length subequal to sclerotized dorso-ventral width of papillae anales. Lamella postvaginalis in ventral view medially united, anteriorly produced ventrad into a double-folded U-shaped flange, medially sclerotically extended cephalad toward dorsal portion of antrum. Antrum dorsally and anterolaterally well sclerotized, ventrally darkened, plicate-membranous. Ductus bursae well sclerotized, left lateral pocket clearly produced.

**Types.** Holotype ♂ PERÚ, Ay[acucho], Apacheta de Tambo, 4250 m, 12°59'S, 74°05'W, 29-I-99, G. Lamas (genitalic dissection # ♂ 6308-CDM), in MUSM. Paratype 1 ♀ PERÚ, Ay[acucho], Rio Apacheta, 4200 m, 13°21'S, 74°39'W, 24-I-99, G. Lamas (genitalic dissection # ♀ 6309-CDM), in MUSM.



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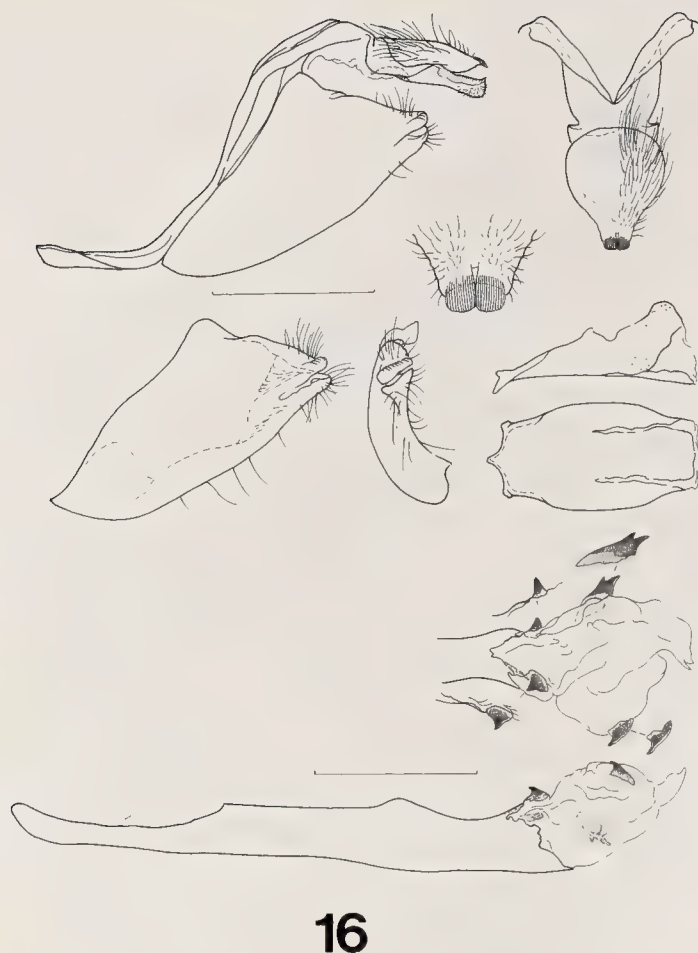
FIG. 15. Male genitalia of *H. pallisteri*, new species holotype. Uncus (lateral and dorsal aspects, dorsal of pectines enlarged), valvae (left outer and caudal aspects, right inner aspect), juxta (left lateral and ventral aspects), penis with vesica everted, (left lateral and distal dorsal aspects). Data as Fig. 1a. Scale = 1 mm.

**Etymology.** The specific name reflects the uncertainty expressed in the discussion below.

**Diagnosis and discussion.** As mentioned, this species is remarkably like *H. blancasi*; in fact when I first saw this pair of specimens I was convinced they were that species. I was surprised by the apparent disjunction of this population from the rather more northern ones of the known *H. blancasi*. In comparing seemingly slight differences in color pattern, stigmal characters, and especially genitalia, I suspected that this was not *H. blancasi*; and since this pair seems to be a male and a female from the same population, I elected to emphasize this, but not without some hesitation—hence the name. The types were collected in January.

The differences from *H. blancasi* in the male genitalia are discussed under that species. The female genitalia resemble those of *H. herrerai* in lacking a sclerotized eighth sternite, but they differ from those of that





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FIG. 16. Male genitalia of *H. pallisteri*? Uncus (lateral and dorsal aspects, dorsal of pectines enlarged), valvae (left outer and caudal aspects, right inner aspect), juxta (left lateral and ventral aspects), penis with vesica everted (left lateral and distal dorsal aspects). Same specimen as in Fig. 1b. Scale = 1 mm.

species in the length of the apophysis anterioris and in the clearly produced lateral pocket of the ductus bursae. There is scarcely any resemblance to that species superficially.

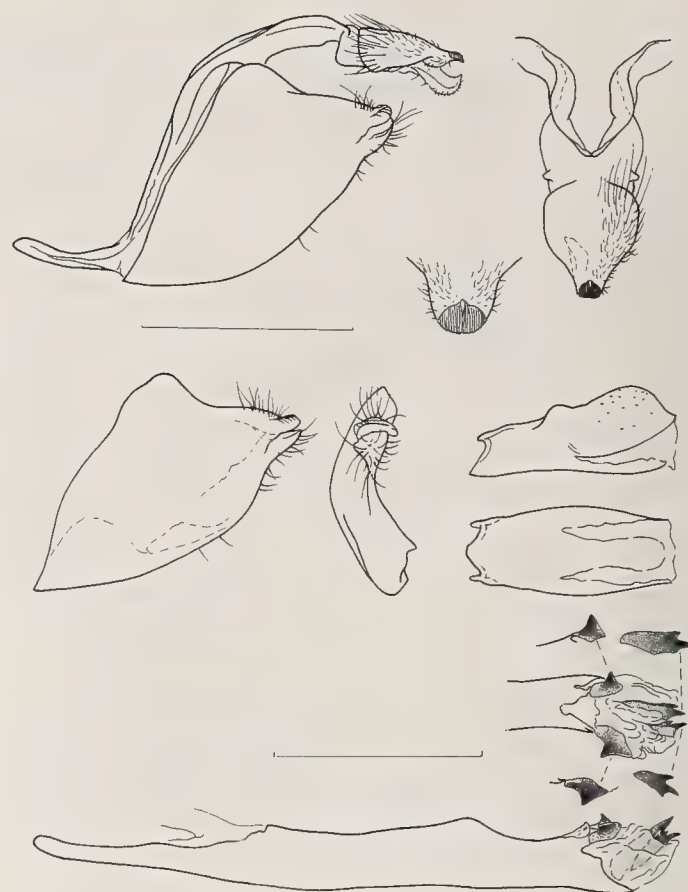
#### SUBGROUP II

##### *Hylephila shapiro* MacNeill, new species

(Figs. 2a, 4g, 19, 42, 58)

*Hylephila* ♀ n. sp., cf. *boulleti* group, Shapiro, 1985. Stud. Neotrop. Fauna and Environ. 20: 9, 10, figs. 5(3), 6(3).

**Description. Male. Head.** Dorsally shaggy with golden hairs. Antennae anteriorly buff, posteriorly black; club about one-half length of shaft; nudum orange-brown; apiculus very short, apparently one abbreviated segment, its width greater than its length. Palpi, second segment shaggy with pale fulvous hairs, hairs black at anterolateral angles; third segment dorsally black-hirsute, ventrally fulvous, not exceeding hairs of second segment. **Body.** dorsally and ventrally black with golden hairs. Tegulae black with broad white edges. Legs with femora black, fringed with golden hairs, tibiae and tarsae white; hind tibia with single pair of spurs. **Wings.** Produced, narrow. Forewing length 8.5 mm ( $n = 1$ ). Above stigma present but very obscure except under magnification, microandroconial mass gray, not nearly extending to origin of vein Cu1, brush patches and

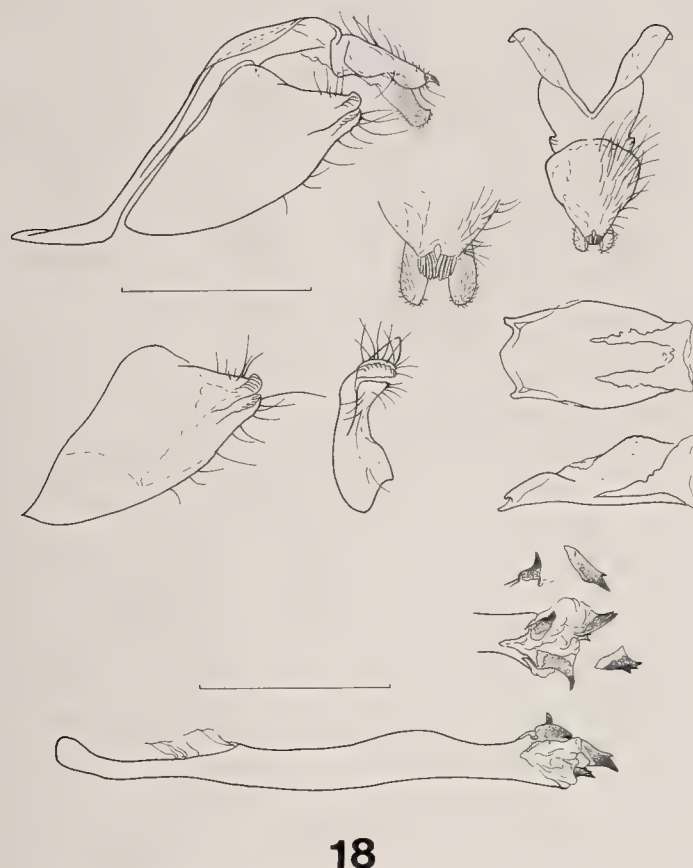


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FIG. 17. Male genitalia of *H. blancasi*, new species holotype. Uncus (lateral and dorsal aspects, dorsal of pectines enlarged), valvae (left outer and caudal aspects, right inner aspect), juxta (left lateral and ventral aspects), penis with vesica everted, (left lateral and distal dorsal aspects). Data as Fig. 1c. Scale = 1 mm.

post-stigmal patches of erect scales absent. Costa white. Broadly fuscous, with extremely pale, nearly hyaline, fulvous spots before end of discal cell, and subapical in spaces R4–R5 and R5–M1, in subterminal spots, (which are nearly continuous with postmedian macular band, not offset), in postmedian band from M1–M2 to Cu1–Cu2; spots of band in Cu2–2A extremely pale fulvous, not nearly hyaline; basad fuscous overscaled fulvous either side of fuscous streak dividing discal cell and costad of discal cell to end cell. Fringes fuscous. Below stigma pocket robust but short, upper element not nearly extending to origin of vein Cu1, diverging from discal cell cubitus vein much closer to vein Cu2 than to vein Cu1; lower elements tiny, uppermost broad (Fig. 2a). Spots as above but fuscous more extensively overscaled fulvous everywhere except in spaces Cu1–Cu2, Cu2–2A, and anal cell; entire costa and veins R4 to M1 distally white. Hindwings above wholly fuscous except for extremely pale fulvous, nearly hyaline, postmedian macular band from space Rs–M1 to M3–Cu1 (in M1–M3 elongate and ray-like from end discal cell) and pale fulvous in space Cu1–Cu2. Fringes fuscous basally, white vannally and terminally. Below, black spots basally in costal and discal cells and space Cu2–2A; postmedially in spaces Sc–Rs, Rs–M1, Cu1–Cu2, and end discal cell; border fuscous spots from distal end spaces Sc–Rs to Cu1–Cu2; space 2A–3A entirely fuscous overscaled fulvous and anal cell black; veins from Sc to Cu2 white;





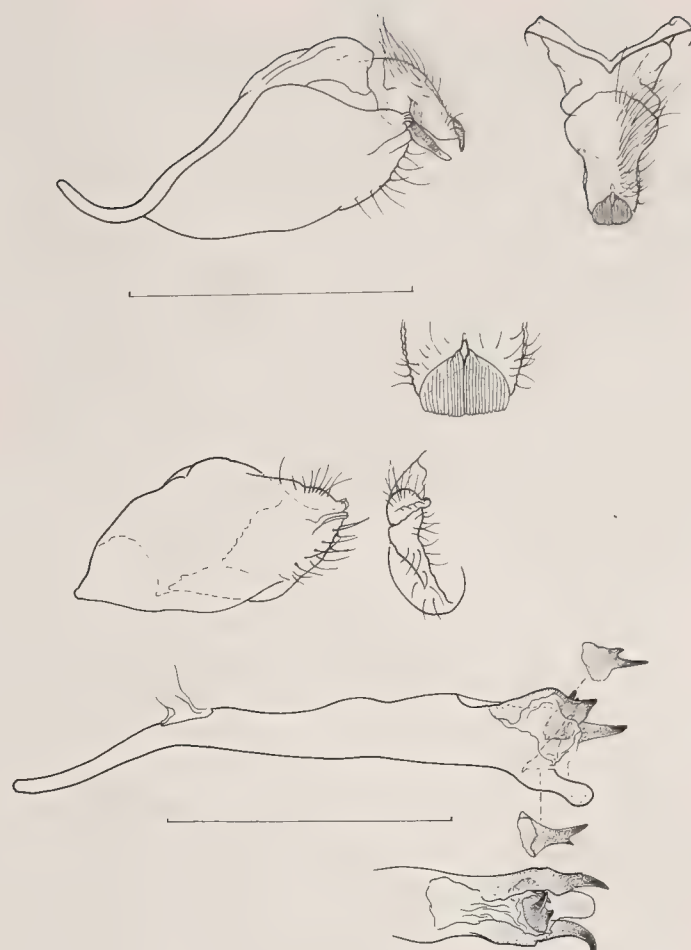
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FIG. 18. Male genitalia of *H. tentativa*, new species holotype. Uncus (lateral and dorsal aspects, dorsal of pectines enlarged), valvae (left outer and caudal aspects, right inner aspect), juxta (left lateral and ventral aspects), penis with vesica everted, (left lateral and distal dorsal aspects). Data as Fig. 1d. Scale = 1 mm.

costa, distal half discal cell, and anterior half of distal two-thirds space Cu2-2A white; posterior half of distal two-thirds space Cu2-2A very pale fulvous, as are the distal portions of pale spots of spaces Rs-M1 to Cu1-Cu2,- that in M1-M3 a streak centrally for distal two thirds, a buff spot discally in space Sc-Rs. Fringes both wings sullied white, white vannally. **Genitalia.** Eighth tergite (Fig. 4g) with lateral margin not distinctly emarginate before caudal margin; terminal bristle-sockets slightly enlarged before caudal margin. Valva (Fig. 19) in lateral view broad, with basal, dorsal, and ventral margins more or less convex, caudal beak not prominent; length basal margin much less than one and one-half depth of valva. Penis proximally reflexed slightly ventrad, its length greatly exceeding length genitalic capsule and more than twice that of valva, elongate ventrocaudally as a terminally rounded, spatulate "floor"; titillators nearly symmetric, huge, laterally compressed thorns, each terminally with slender hooks laterad, sclerotically strapped to penis; cornuti asymmetric, minutely bidentate. Juxta severely damaged, not definable. Uncus in dorsal view, anterior half rounded, posterior half parallel-sided, where scarcely minutely serrate to pectines; pectines large, each half medially longer than broad, anteriorly tapered to cleft, posteriorly truncate, the tines numerous, inconspicuous, in lateral view pectines dorsally arched. Gnathos in lateral view mostly membranous, narrowly sclerotized dorsad, not divergent nor exceeding pectines caudad, but uncus caudad and pectines slightly arched dorsad from gnathos.

**Female.** Unknown.

**Type.** Holotype ♂ PERÚ, Dept. Junín, vic. Abra Anticona, 4843 m, X-19-83, A. M. Shapiro (genitalic dissection # ♂ 5005-JH), in CAS.



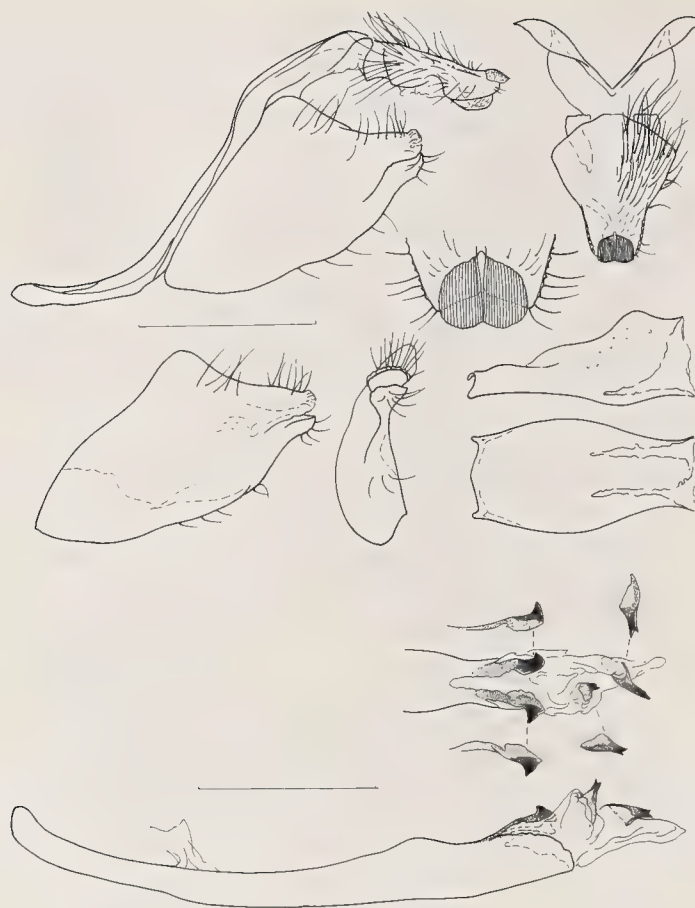
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FIG. 19. Male genitalia of *H. shapiro*, new species holotype. Uncus (lateral and dorsal aspects, dorsal of pectines enlarged), valvae (left outer and caudal aspects, right inner aspect), penis with vesica everted, (left lateral and distal dorsal aspects). Data as Fig. 2a. Scale = 1 mm.

**Etymology.** I am delighted to name this remarkable little species for Arthur M. Shapiro, the collector of the only known specimen. Art has provided enormous and continuous support throughout these studies with years of discussion and careful collecting in South America.

**Diagnosis and discussion.** This small species dorsally appears to be more black and white rather than black and fulvous, and it does not seem to have a stigma until it is examined under magnification. The single pair of spurs on the metathoracic tibiae is a unique characteristic of this species within the *boulleti* group of *Hylephila*. This specimen was figured by Shapiro (1985) in his paper summarizing behavioral and ecological observations of the high altitude pierines he studied. In that paper, he discussed the morphospecializations of the genus *Phulia* Herrich-Schäffer and suggested that the convergence of the high altitude hesperiid fauna to the "dashed *Phulia* pattern" of high Andean pierines was owing to adapta-





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FIG. 20. Male genitalia of *H. galera*? Uncus (lateral and dorsal aspects, dorsal of pectines enlarged), valvae (left outer and caudal aspects, right inner aspect), juxta (left lateral and ventral aspects), penis with vesica everted, (left lateral and distal dorsal aspects). Data as Fig. 2c. Scale = 1 mm.

tion for crypsis. The type was collected in October flying with *H. peruana*.

#### *Hylephila galera* Evans

(Figs. 2b, 2c, 2d, 5a, 5b, 20, 21, 43, 44, 45, 58)

*Hylephila galera* Evans, 1955. Cat. Amer. Hesp. part IV, p. 314, pl. 75. Bridges, 1983, Lepid.:Hesp. Notes on species group names, part 1:47.

In the description below, brackets, indicate remarks not taken from the type but from specimens #6121 and/or #6307.

**Description. Male. Head.** Dorsally black with orange hairs; antennae with club about one-half length of shaft, anteriorly buff merging dorsally to fulvous and ventrally to white, posteriorly black with scattered fulvous to white scales, nudum orange-brown, apiculus with ultimate segment slightly longer than wide; palpi missing [6121: palpi with third segment evident but scarcely exceeding long, hair-like vestiture of second segment]. **Body.** [6121: dorsally black with long golden hairs, ventrally black with long, shaggy, fulvous hairs. Legs black, overscaled buff, with long fringes of orange hairs, hind tibiae with two pairs of spurs]. **Wings.** Broad, rounded. Forewing length 13 mm [range 13–14 mm] (n = 3) Above, stigma

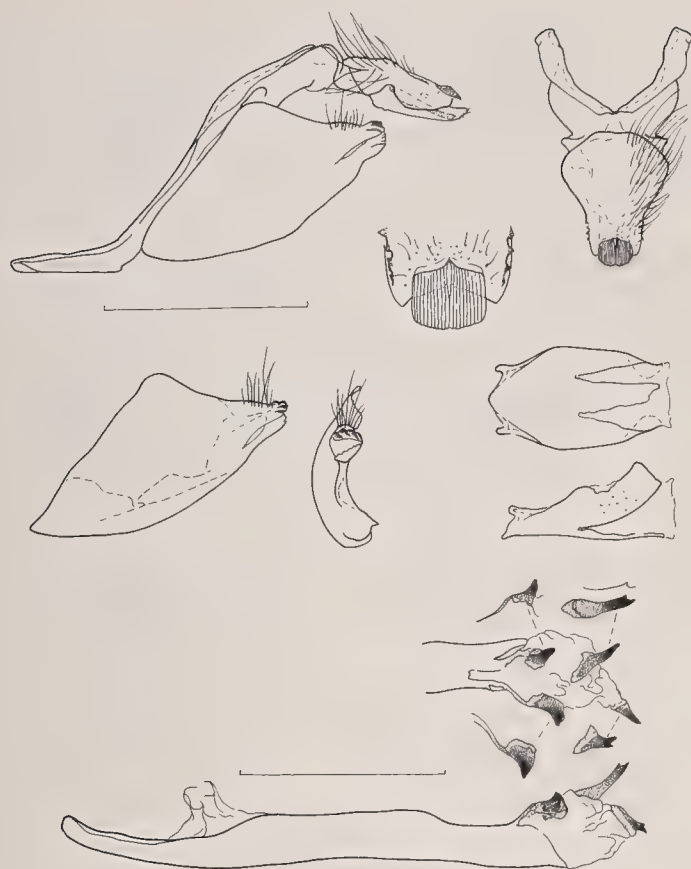


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FIG. 21. Male genitalia of *H. galera*? Uncus (lateral and dorsal aspects, dorsal of pectines enlarged), valvae (left outer and caudal aspects, right inner aspect), juxta (left lateral and ventral aspects), penis with vesica everted, (left lateral and distal dorsal aspects). Data as Fig. 2d. Scale = 1 mm.

conspicuous but narrow, apical and lower brush patches evident, as is the rather narrow post-stigmal patch [6121: microandroconial mass dark brown]. Fulvous extensive, conspicuously penetrating wide fuscous border along veins to termen, inner edge subterminal fulvous spots offset from inner edge postmedian macular band; fringes basally fuscous, terminally orange. Below, stigma pocket narrow, upper element extends proximad from just beyond origin of vein Cu1, diverges from discal cell cubitus vein much closer to origin of vein Cu1 than to Cu2, and does not nearly reach vein Cu2; lower elements well separated from veins Cu2, 2A, and from each other (Fig. 2b). [6121: upper element stigma pocket extends just beyond origin vein Cu1 and diverges from discal cell cubitus vein about equidistant from origins veins Cu1 and Cu2, without quite reaching vein Cu2; lower elements small, well separated (Fig. 2c); #6307: upper element nearly reaching vein Cu2, lower elements large, not widely separated (Fig. 2d)]. Fulvous extensive, costa and veins not whitened [6121, 6307: veins R4 to M1 and costa whitened, at least under magnification], but veins R5 and M1 much paler distad. Hindwings above fulvous as on forewings penetrating border to termen. Below rich fulvous very extensive, entering lower half of discal cell nearly or quite to base, none of the veins whitened [6121, 6307: veins of discal cell and from Rs to Cu2 white under magnification]. Fringes both wings basally sullied orange [6121: or fuscous], terminally orange [6121: or white]. **Genitalia.** Badly damaged; uncus eaten, penis, vinculum partly eaten, saccus missing, valvae damaged, titillators and cornuti intact but not everted. [6121 6307: eighth tergite lateral margin broadly concave and abruptly emarginate before caudal margin (Figs. 5a, b). Valvae (Figs. 20, 21) in lateral view somewhat broad, ventral and basal





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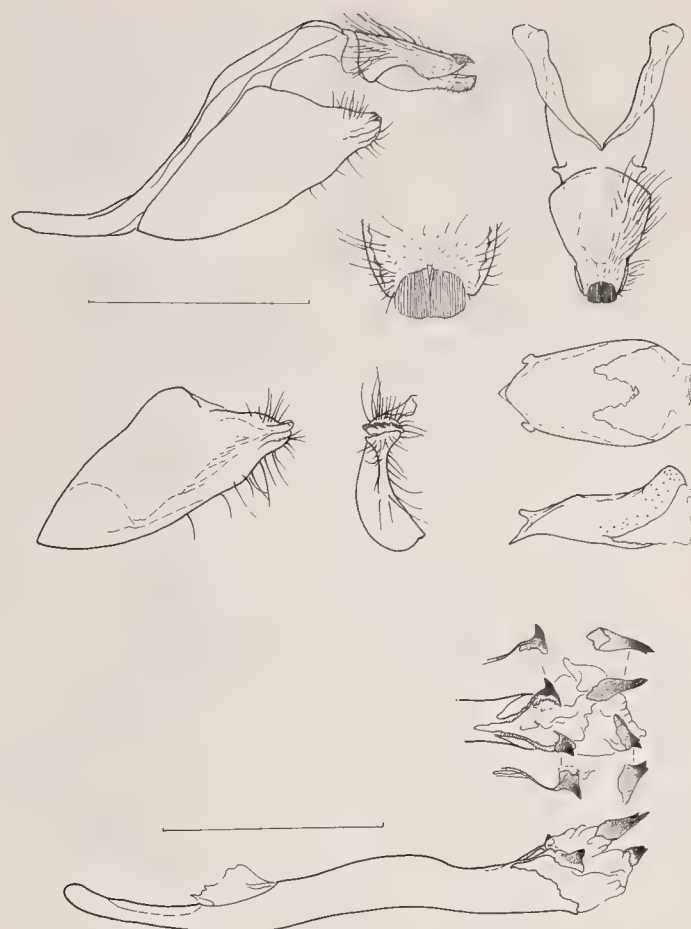
FIG. 22. Male genitalia of *H. bouletti*. Uncus (lateral and dorsal aspects, dorsal of pectines enlarged), valvae (left outer and caudal aspects, right inner aspect), juxta (left lateral and ventral aspects), penis with vesica everted (left lateral and distal dorsal aspects). Data as Fig. 5c. Scale = 1 mm.

margins gently convex, dorsal margin and ventral margins caudally concave to caudal beak; length basal margin about one and one-half times depth of valva. Penis proximally curved dorsad, its length subequal to length of genitalic capsule and almost twice length of valva; titillators short, thorn-like, sclerotically strapped to penis; cornuti nearly symmetric, very narrowly bidentate. Juxta with ventrocaudal clefts long, nearly one-half length of juxta. Uncus in dorsal view roughly triangular, not distinctly rounded cephalad, laterally abruptly angled posteriorly one-half distance to very gradually tapered, laterally serrate, posterior half to caudal pectines, the caudal cleft not or scarcely exceeding pectines cephalad; pectines large, each half slightly longer than broad, anteriorly rounded, posteriorly emarginate, the tines numerous, inconspicuous. Gnathos in lateral view scarcely sclerotized, not exceeding pectines caudad, and not divergent ventrally from uncus].

**Female.** Unknown.

**Type.** Holotype ♂ PERÚ, Dept. Junín, Galera Pass, 4800 m, II-?-00 (Simons), "snowy season," in BMNH.

**Discussion.** The two additional specimens I have seen I believe represent this species, but they differ somewhat from the type, most particularly in the elements of the stigma pockets. Neither has the upper element as reduced as does the type, and # ♂ 6307 has the lower elements very much larger and proximate



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FIG. 23. Male genitalia of *H. bouletti*. Uncus (lateral and dorsal aspects, dorsal of pectines enlarged), valvae (left outer and caudal aspects, right inner aspect), juxta (left lateral and ventral aspects), penis with vesica everted (left lateral and distal dorsal aspects). Data as Fig. 5d. Scale = 1 mm.

(Fig. 2d). These specimens will be placed in the following collections: #6121, from Tarma, Junín, Perú, 3000 m, in LACM, and #6307, from Yauli, Corpacancha, Junín, Perú, 4300 m, in MUSM. This species flies in January and February.

*Hylephila bouletti* (Mabille)

(Figs. 3a, 3b, 5c, 5d, 7, 10, 22, 23, 28, 29, 46, 47, 48, 49, 50, 51, 59)

*Chaerephon bouletti* Mabille, 1906. Bull. Soc. Entomol. France, no. 6:67-68.

*Hylephila bouletti*, Ureta, 1956. Bol. Mus. Nat. Hist. Nat. 26: 176, pl. 2, fig. 5b-5d; MacNeill & Herrera, 1999, J. Lepid. Soc. 52:291.

*Hylephila bouletti* (sic) *bouletti*, Ureta, 1963. Bol. Mus. Nac. Hist. Nat. 28:78,79.

*Hylephila bouletti bouletti*, Evans, 1955. Cat. Amer. Hesp. part IV, p. 314, pl. 755; Hayward, 1973. Opera Lilloana 23:93; Lewis, 1973, Butterflies of the World, p. 246, pl. 83, fig. 17; Bridges, 1983,



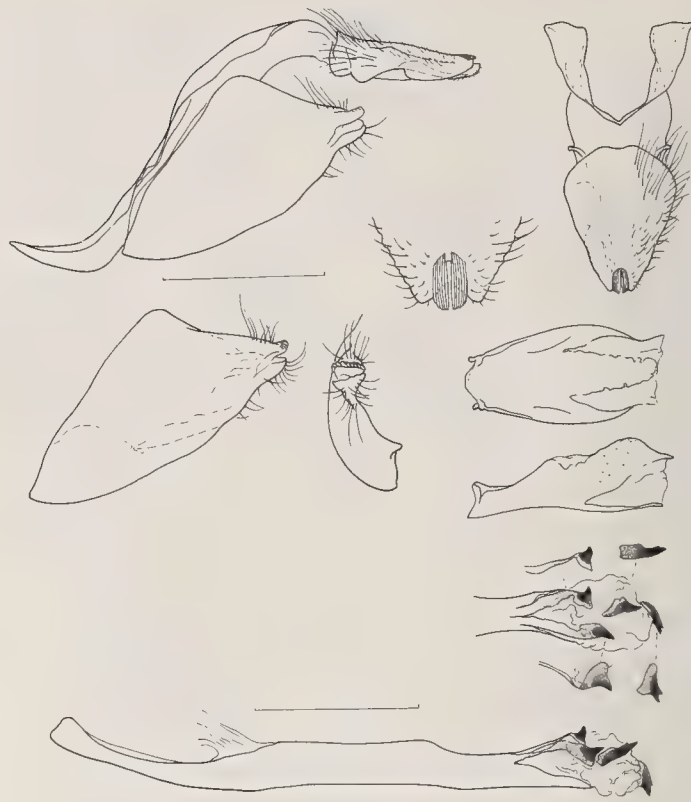


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FIG. 24. Male genitalia of *H. rossi*, new species holotype. Uncus (lateral and dorsal aspects, dorsal of pectines enlarged), valvae (left outer and caudal aspects, right inner aspect), juxta (left lateral and ventral aspects), penis with vesica everted (left lateral and distal dorsal aspects). Data as Fig. 3c. Scale = 1 mm.

Lepid.: Hesp. Notes on species group names, part 1:18; Shapiro, 1993, J. Res. Lepid. 30:163, 164; Peña & Ugarte, 1997, Las mariposas de Chile, the butterflies of Chile, p. 128, figs.

**Description. Male. Head.** Dorsally very pale fulvous, with long, black hair-like scales rising from paired, postmedial black scale patches which are separated by smaller, triangular, medial patch on the vertex; pale, fulvous hair-like scales elsewhere except for mixed black and fulvous eyelash scales. Antennae anteriorly pale buffy to white, posteriorly black; club about one-half length of shaft; nudum pale orange to orange brown on apiculus; apiculus about three short segments, its basal width about equal to its length. Palpi third segment black, ventrally mostly pale fulvous to buff, clearly to scarcely emergent from shaggy vestiture of second segment, where antero-lateral angles have scattered black hairs. **Body** dorsally black with scattered, long, pale golden vestiture of hair-like scales concentrated medially, pectus and venter white to pale fulvous. Legs mostly white, fringed fulvous, hind tibiae with two pairs of spurs, the upper occasionally somewhat reduced. **Wings.** Somewhat pointed apically, not stubby. Forewing average length 10.7 mm [range 9–13 mm] ( $n = 40$ ). Above, stigma slender, conspicuous, microandroconial mass inconspicuous without magnification, gray or tan to (rarely) yellow, apical and lower brush patches present, poststigmatal patch conspicuous but not broad. Fulvous pale tawny, very variable in extent (cf. Figs. 46

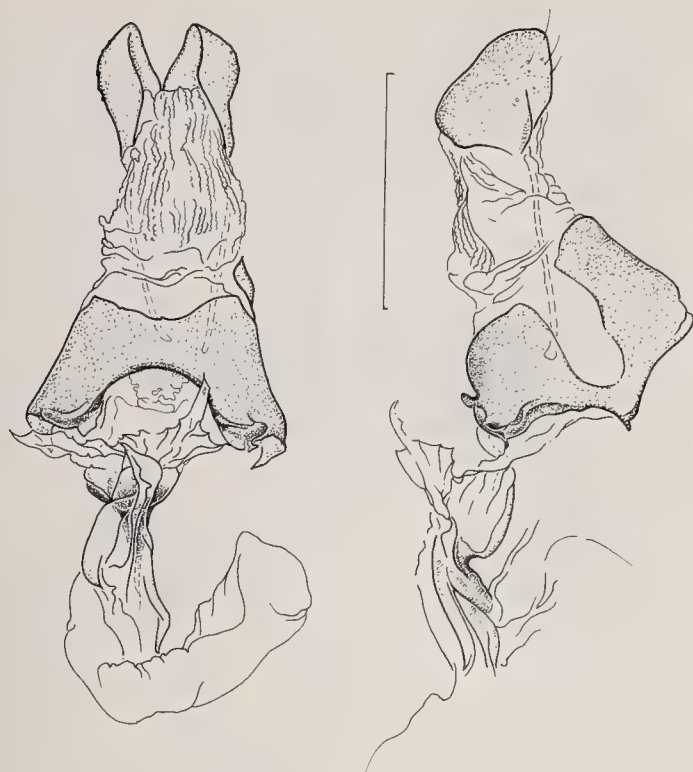


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FIG. 25. Male genitalia of *H. peruana*. Uncus (lateral and dorsal aspects, dorsal of pectines enlarged), valvae (left outer and caudal aspects, right inner aspect), juxta (left lateral and ventral aspects), penis with vesica everted (left lateral and distal dorsal aspects). Data as Fig. 3d. Scale = 1 mm.

and 48); fuscous border if broad and clearly cut by fulvous veins, the fulvous not reaching termen along veins. Below, stigma pockets slender (Figs. 3a, b), diverging from discal cell cubitus vein about equidistant from origins of veins Cu1 and Cu2 or usually slightly nearer to that of vein Cu1 (but see Fig. 3b). Fulvous more extensive, costa and most veins whitened distally to termen. Fringes pale, basal third fuscous, middle third light fulvous, terminal third white. Hindwings above as forewings, variable, border broad or narrow, usually not cut to termen by fulvous along veins. Postmedian macular band conspicuous, usually extending ray-like into at least lower part of discal cell from space M1–M3 and from vein 2A to Rs. Vein 2A fulvous from base to termen defining vannal fuscous area. Below pale fulvous to almost white. Costa and all veins whitened, often including vein 3A, vannal area fuscous. **Genitalia.** Eighth tergite (Figs. 5c, d) with lateral margin broadly concave or sinuate cephalad, not distinctly emarginate just before caudal margin; terminal bristle-sockets rounded in cross section and enlarged before caudal margin (Fig. 7). Valva (Figs. 22, 23) in lateral view broad, ventral margin convex, basal margin straight, dorsal margin slightly concave to caudal beak where knobs dorsad of caudal horizontal cleft few; length basal margin about equal to one and one-half depth of valva. Penis proximally slightly curved dorsad, its length slightly greater than length of genital capsule and less than twice length of valva; titillators large, asymmetric, the left very broadly and the right more narrowly thorn-like, both sclerotically strapped to penis; cornuti asymmetric, one long, narrow, and basally very elongate, the other short, thorn-like, both minutely bidentate. Juxta broad, not elongate, with ventrocaudal clefts long, about one-half length of juxta, separated median floor nearly or quite reaching caudal margin of juxta. Uncus in dorsal view





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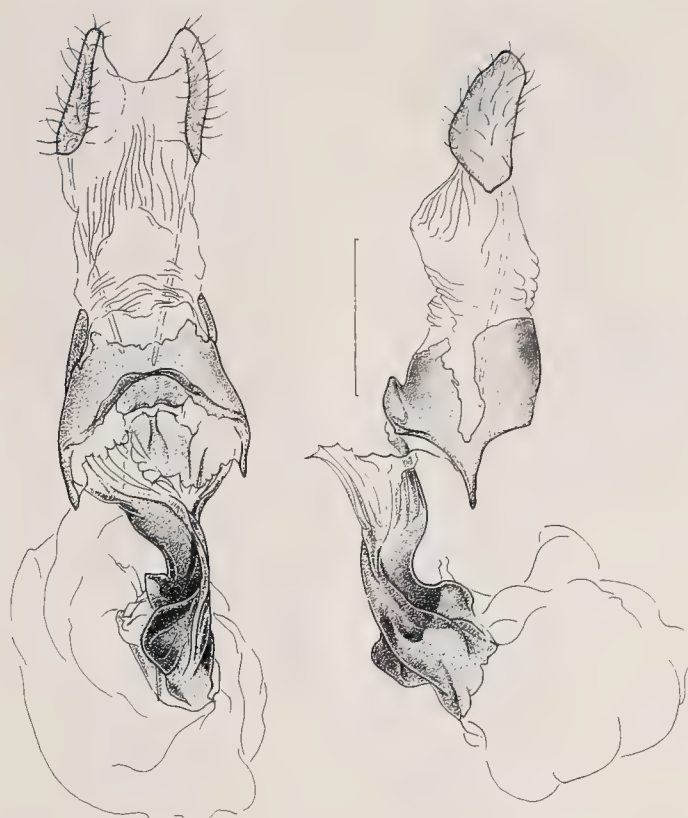
FIG. 26. Female genitalia of *H. herrerae*, new species, paratype (ventral and right lateral aspects). CHILE, Parinacota, "Arica," Cotacotani, 4500 m, II-28-48, (genitalic dissection # ♀6118-CDM) in CAS. Scale = 1 mm.

with lateral margins broadly angulate at anterior one-fourth, then emarginate to nearly parallel-sided caudal one-third, where minutely serrate to caudal tip which exceeds width of pectines, caudal cleft scarcely exceeding pectines cephalad; pectines not minute, length each half usually about twice its breadth, anteriorly and posteriorly nearly or quite truncate; the tines many, inconspicuous. Gnathos in lateral view scarcely sclerotized, slightly exceeding pectines caudad, and not very divergent ventrally from uncus.

**Female. Head.** As male, antennal shaft about twice length of club. **Wings.** Tawny to very pale fulvous (Figs. 47, 49). Forewing, average length 11.9 mm [range 10–15 mm] ( $n = 35$ ). Dorsal surface as male; ventral surface pale fulvous much expanded, fuscous border greatly reduced, or faded to nearly obsolete. **Genitalia.** Eighth sternite in ventral view sclerotized and broadly crescentic, its greatest width caudolaterally, its length about one-fourth to one-third its width. Apophysis anterioris in lateral view (Figs. 28, 29) somewhat to scarcely produced cephalad of junction with lamella postvaginalis. Lamella postvaginalis in ventral view narrowly united, each half produced ventro-cephalad forming a slight anterior bulge, not nipple-like, medially not produced ventrally. Antrum dorsally sclerotized and with a longitudinal fold, ventrally caudal and lateral one-half membranous. Ductus bursae well sclerotized, in right lateral view ductal constriction not very abrupt, the sinus U-shaped; left lateral pocket slightly to prominently produced.

**Type.** Mabilles's type, a female, is presumably in the Muséum National Histoire Naturelle, in Paris, France. It was collected in Perú.

**Diagnosis and discussion.** The material from Argentina I have seen (8 specimens) is all from the pre-



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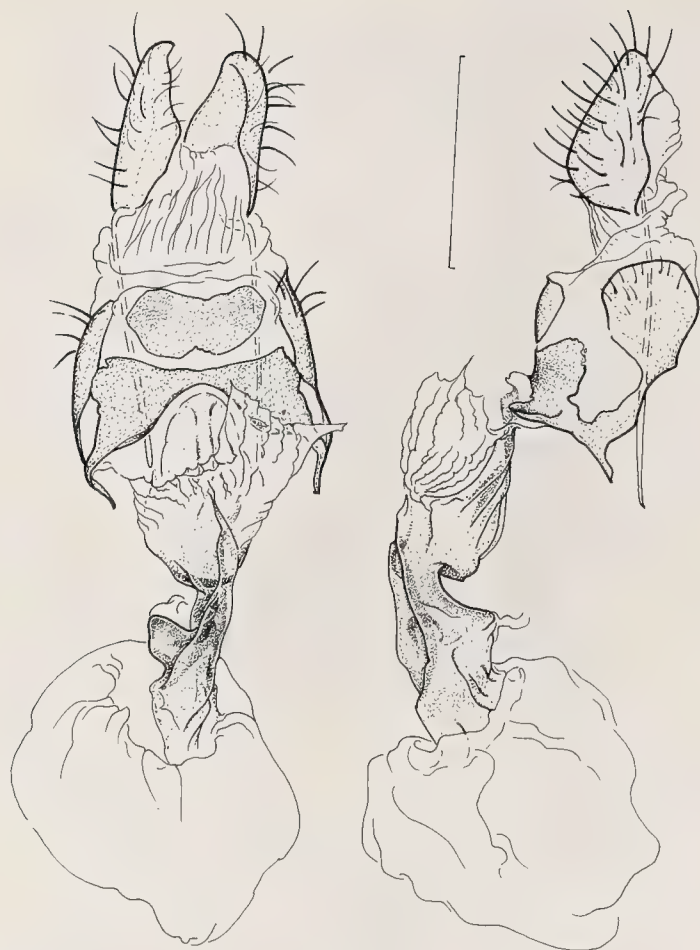
FIG. 27. Female genitalia of *H. tentativa*, new species, paratype (ventral and right lateral aspects). PERÚ, Ayacucho, Rio Apacheta 4200 m, 13°21'S, 74°39'W, I-24-99, G. Lamas, (genitalia dissection # ♀6309-CDM), in MUSM. Scale = 1 mm.

Andean Nevadas del Aconquija, just west of San Miguel de Tucumán in provincias Catamarca and Tucumán. The males (4 specimens) are somewhat variable in their genitalia (see Fig. 23, # ♂ 6213, from Catamarca) and may not represent a single species, but I am content to consider them all minor variations of *H. bouletti* until such time as more and better material can be studied.

Males of *H. bouletti* have a stigma with a microandroconial mass that is usually neither conspicuous nor yellow, they have two pairs of metathoracic tibial spurs, and usually lack wing borders above that are deeply and broadly cut by fulvous along the veins. This species is very pale fulvous above, not orange fulvous; and it seems to fly alone, not within the ranges of most other species of the *bouletti* group, save for *H. herrerae*. Its range does evidently overlap those of the next species and of *H. peruana* slightly in a narrow region of Puno, Perú, northwest of Lago Titicaca near the border of Departamento Cuzco (Fig. 59). *Hylephila bouletti* seems to be on the wing through most of the year except for June through August.

This species is the most commonly collected mem-

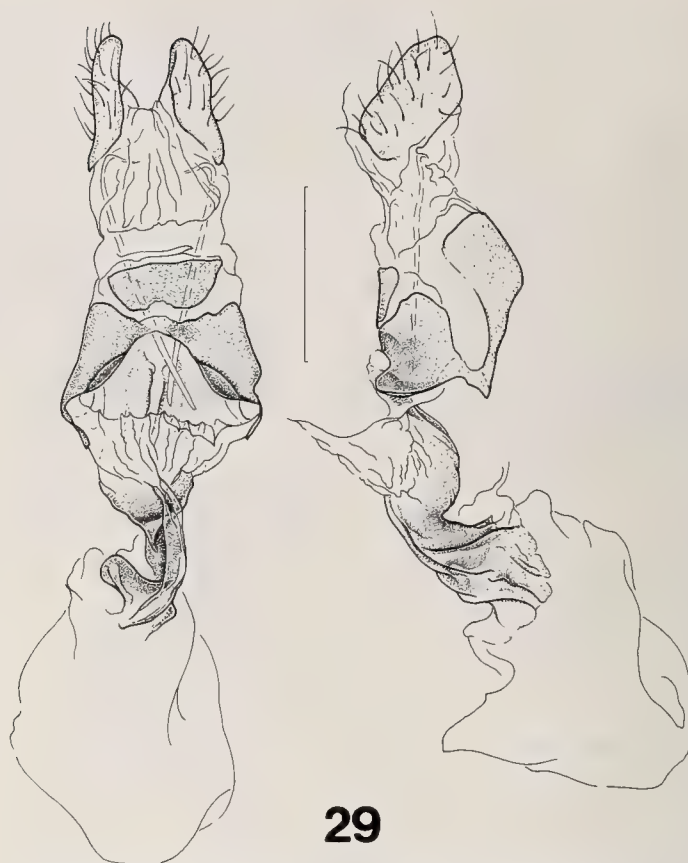




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FIG. 28. Female genitalia of *H. bouletti* (ventral and right lateral aspects). CHILE, El Loa, Geiser el Tatio, 4360 m, I-29-65, J. Herrera, (genitalic dissection # ♀6218-CDM), in CAS. Scale = 1 mm.

ber of the *bouletti* group. Indeed, I have seen a total of 55 males and 40 females (27 males, 23 females dissected) representing 32 localities in Perú, Chile, Bolivia, and Argentina; but the samples almost always consisted of one to three specimens, except for one locality in Chile and another in Argentina; where the sample was six specimens. It wasn't until the mid-1990's when Arthur M. Shapiro made five collections, under a CONAF collection permit issued 18 November 1994 in Arica, Chile, by Juan Silva, Director, CONAF, 1st region, that samples of up to 25 were taken. Shapiro 1995, in litt. stated that at one locality the *H. bouletti* "were as common as I have ever seen any skipper anywhere; I could have taken hundreds, if not thousands." The skippers were (in his words) "incredibly abundant on monocultures of the apparent host (oviposition substrate), *Deyeuxia breviaristata* Wedd., a small wiry grass that grows just (above) the margins of boggy and saline environments." The fa-



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FIG. 29. Female genitalia of *H. bouletti* (ventral and right lateral aspects). ARGENTINA, Tucumán, Huaca Huasi, Lago Nostra, 4250 m, XII-26-78, Halloy, (genitalic dissection # ♀6214-CDM), in IML. Scale = 1 mm.

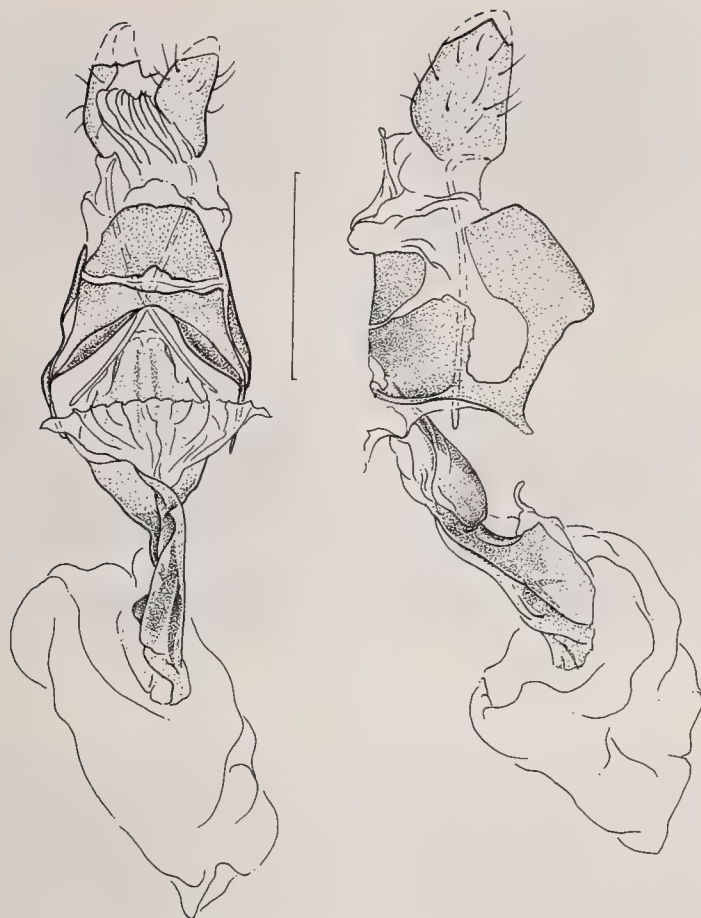
vored nectar source was a small composite, *Werneria*, that grows flat on the ground in boggy turf, (fide Shapiro). He observed oviposition on *Deyeuxia*, often on plants that seemed dry and desiccated, presumably owing to the rains having just started.

Twenty-three ova were recovered by dissection prior to KOH treatment (see MacNeill & Herrera 1999:279) from three females (# ♀ 6218, # ♀ 6264, and # ♀ 6265), and these averaged 0.8 mm in diameter and 0.58 mm in height. The diameter ranged from 0.75 to 0.83 mm, and the height ranged from 0.55 to 0.65 mm. The three females separately had different averages: # ♀ 6218 measured the largest with 9 ova averaging  $0.82 \times 0.60$  mm, and # ♀ 6265 measured the smallest with 8 ova averaging  $0.78 \times 0.57$  mm. The most common (not average) measurement of the 23 ova was  $0.8 \times 0.6$  mm, a fairly high-domed egg, by and large. The reticulation was very weakly evident at 100× magnification.

#### *Hylephila rossi* MacNeill, new species (Figs. 3c, 24, 30, 52, 53, 58)

**Description. Male. Head.** Vestiture buff tinted fulvous mixed with black hairs, eyelash black. Palpi with mostly black third segment emergent from buff hairs of second segment. Antennal club

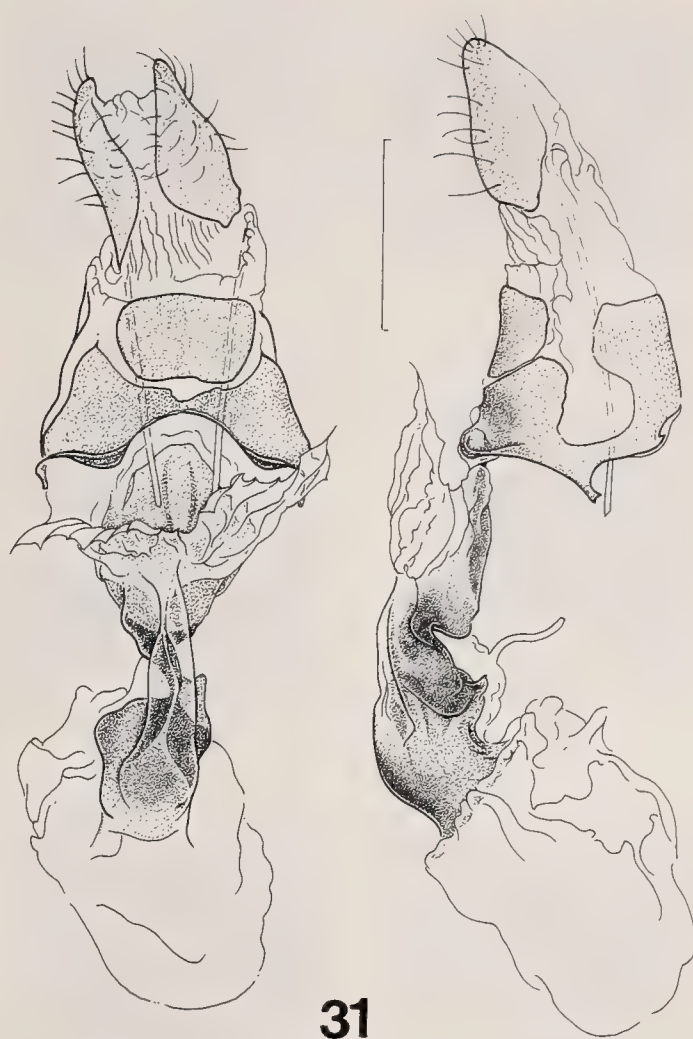




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FIG. 30. Female genitalia of *H. rossi*, new species, paratype (ventral and right lateral aspects). PERÚ, Cuzco-Puno, La Raya, 4318 m, IV-19-71, J. Herrera, (genitalic dissection # 93829-JH), in CAS. Scale = 1 mm.

anteriorly buff merging to fulvous and black above, to white below, posteriorly black; nudum orange-brown, apiculus width equal to length; shaft more than twice club length. **Body.** Hind legs missing. **Wings.** Narrow, pointed. Forewing length 12.5 mm ( $n = 1$ ). Stigma rather narrow; microandroconial mass brownish gray; apical, middle, and lower brush patches present; post-stigmal patch fairly broad. Orange-fulvous of apical, and subterminal spots, also of narrow postmedian macular band (offset from the subterminal spots), and of lower one-half of discal cell (expanded end cell), somewhat restricted by fuscous of costal area, of upper half of discal cell, of space Cu2-2A basad of stigma, and of broad, slightly indented border. Fringes above fuscous. Below, upper element of stigma pocket diverging from cubitus vein of discal cell about equidistant between origins of veins Cu1 and Cu2, extending nearly or quite basad to vein Cu2, lower elements large (Fig. 3c), veins not whitened. Hindwing above with orange-fulvous very restricted to posterior arm of postmedian macular band from M1-M3 to Cu1-Cu2, and vein 2A also fulvous. Below fulvous expanded to base in space Cu2-2A and in anterior arm of postmedian macular band across space Rs-M1. Veins buff, slightly paler than fulvous ground color, but not whitened. Fringes sullied orange, vannally orange. **Genitalia.** Eighth tergite lateral margin broadly concave, not emarginate just before caudal margin; terminal bristle-sockets slightly enlarged before caudal margin. Valva (Fig. 24) in lateral view somewhat narrow, ventral margin convex, caudally emarginate to beak, basal margin straight, dorsal margin slightly concave to caudal beak where knobs dorsad of horizontal cleft several; length basal margin about equal to one and one-half depth of valva. Penis proximally slightly curved



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FIG. 31. Female genitalia of *H. peruana* (ventral and right lateral aspects). PERÚ, Junín, Pachachaca, 4201 m, IV-9-71, J. Herrera (genitalic dissection # 93872-JH), in CAS. Scale = 1 mm.

dorsad, its length exceeding length of genitalic capsule but not twice length of valva; titillators small, nearly symmetric, broadly thorn-like, sclerotically strapped to penis; cornuti three, asymmetric, one slender, elongate, minutely bidentate, the others small, thorn-like, unidentate. Juxta narrow, elongate, with ventrocaudal clefts not quite one-half length of juxta, separated median floor not reaching caudal margin of juxta. Uncus in dorsal view more or less triangular, posteriorly tapered (where minutely serrate) to caudal tip which scarcely exceeds width of pectines, caudal cleft scarcely exceeding pectines cephalad; pectines small, length each half less than twice its breadth, anteriorly and posteriorly nearly truncate; in lateral view uncus dorsally arched, pectines conspicuously so. Gnathos in lateral view scarcely sclerotized, not divergent ventrally from uncus, and not exceeding pectines caudad.

**Female. Head.** As male but buff areas paler. **Body.** Hind tibia with upper pair of spurs much reduced, lower pair long. **Wings.** Forewing length 12.5 mm ( $n = 1$ ). Above, markings rich fulvous, restricted slightly more than in male, but subterminal spots inclined and scarcely offset from postmedian macular band. Hindwing with fulvous along veins penetrating fuscous border nearly to termen. Below, fulvous expanded; veins Rs to Cu2 somewhat whitened. Fringes both wings above and below sullied white. **Genitalia.** Eighth sternite in ventral view broad, its greatest transverse width cephalad about twice its length. Apophysis anterioris in lateral view (Fig. 30) produced somewhat cephalad of junction with lamella postvaginalis.





FIGS. 32–37. Adults of species of *Hylephila*, left side = dorsal surface; right side = ventral surface; approximately 1×. **32**, *H. herrerae*, new species holotype ♂, same specimen as in Fig. 4a. **33**, *H. herrerae*, new species, paratype ♀, same specimen as in Fig. 26. **34**, *H. pseudoherrerae*, new species holotype, same specimen as in Fig. 4b. **35**, *H. pseudoherrerae*, new species, paratype ♂, same specimen as in Fig. 4c. **36**, *H. pallisteri*, new species holotype ♂, same specimen as in Fig. 1a. **37**, *H. pallisteri*?, ♂, same specimen as in Fig. 1b.

Lamella postvaginalis in ventral view very narrowly united forming a distinct V at the junction, from which, in lateral view, each half produced but scarcely bulging cephalad. Antrum dorsally sclerotized and with longitudinal fold, caudal half membranous ventrally and laterally. Ductus bursae sclerotized, left lateral pocket evident in lateral view but not prominent.

**Types.** Holotype ♂ PERÚ, (Puno), 10 mi N. of Ayaviri, III-1-51, E. S. Ross & A. E. Michelbacher (genitalic dissection # ♂ 3821-JH), in CAS. Paratype. 1 ♀ PERÚ, Cuzco-Puno, La Raya, 4318 m, IV-19-71, J. Herrera (genitalic dissection # ♀ 3829-JH), in CAS.

**Etymology.** This species is named for Edward S. Ross, curator emeritus of the California Academy of Sciences, one of the collectors of the single male known.

**Diagnosis and discussion.** *Hylephila rossi* is closely related to *H. bouletti*, and the two known specimens are from the only region of overlap known be-

FIGS. 38–45. Adults of species of *Hylephila*, left side = dorsal surfaces; right side = ventral surfaces. Approximately 1×. **38**, *H. blancasi*, new species holotype ♂, same specimen as in Fig. 1c. **39**, *H. blancasi*, new species, paratype ♂, PERÚ, Huanuco, illegible locality, Holland collection, (genitalic dissection # ♂ 6280-CDM), in CMNH. **40**, *H. tentativa*, new species holotype ♂, same specimen as in Fig. 1d. **41**, *H. tentativa*, new species, paratype ♀, same specimen as in Fig. 27. **42**, *H. shapiroei*, new species holotype ♂, same specimen as in Fig. 2a. **43**, *H. galera*, holotype ♂, same specimen as in Fig. 2b. **44**, *H. galera*? ♂, same specimen as in Fig. 2c. **45**, *H. galera*? ♂, same specimen as in Fig. 2d.

tween *H. bouletti* and *H. peruana* (Figs. 58, 59). This species is much darker with much less fulvous above in both sexes than *H. bouletti*, and the fulvous is much more orange than the pale fulvous of the latter. Both





46



47



52



53



48



49



54



55



50



51



56



57

FIGS. 46–51. Adults of species of *Hylephila*, left side = dorsal surfaces; right side = ventral surfaces. Approximately 1×: **46**, *H. bouletti*, ♂, same specimen as in Fig. 3a, **47**, *H. bouletti*, ♀, same specimen as in Fig. 28. **48**, *H. bouletti*, ♂, CHILE, Parinacota, Reserv. Nac. Salar de Surire, no. shore, 4250 m, XI-22-94, A. M. Shapiro, in CAS. **49**, *H. bouletti*, ♀, same data as specimen in Fig. 48. **50**, *H. bouletti*, ♂, same specimen as in Fig. 5d. **51**, *H. bouletti*, ♀, ARGENTINA, Tucumán, Las Animas Portezuelo, 4540 m, I-26-79, Dominquez, in AMNH.

the male and female genitalia of each are also slightly different (cf. Figs. 22, 24 and Figs. 28, 30). It flies during March and April.

*Hylephila peruana* Draudt

(Figs. 3d, 5e, 8, 11, 25, 31, 54, 55, 56, 57, 59)

*Hylephila lima* (sic) Dyar (nec Plötz), 1913. Proc. U.S. Nat. Mus. 45:639.

*Hylephila peruana* Draudt, 1923 [in Seitz] Gross Schmet. Erde 5:929, pl. 180 f.; MacNeill & Herrera, 1999. J. Lepid. Soc. 52:279–280, 291.

*Hylephila bouletti peruana*, Evans, 1955. Cat. Amer. Hesp. part IV, p. 314; Bridges 1983. Lepid. Hesp. notes on species group names, part 1:92; Mielke, 1993. Rev. Bras. Entomol. 37:622, figs. 93–97;

FIGS. 52–57. Adults of species of *Hylephila*, left side = dorsal surfaces; right side = ventral surfaces. Approximately 1×: **52**, *H. rossi*, new species holotype ♂, same specimen as in Fig. 3c. **53**, *H. rossi*, new species, paratype ♀, same specimen as in Fig. 30. **54**, *H. peruana*, ♂ same specimen as in Fig. 3d. **55**, *H. peruana* ♀, same specimen as in Fig. 31. **56**, *H. peruana* ♂, PERÚ, Cuzco, Cuzco-Olantaitambo Rd., VII-7-84, 3000 m, S. Courtney & P. Stern, in CAS. **57**, *H. peruana* ♀ PERÚ, Junín, vic. Abra Anticona, 4843 ± 100 m, X-19-83 A. M. Shapiro (genitalic dissection # ♀ 6143-CDM), in CAS.

Mielke & Schroeder, 1994. Senckenberg. Biolog. 73:142, fig. 20.

*Hylephila bouletti perunana*, (lapsus) Shapiro, 1985. Stud. Neotrop. Fauna and Environ. 20:9,10, figs. 5(1), 6(1).

**Description. Male. Head.** Vestiture buff, tinted orange; eyelash black. Palpi with third segment dorsally black, ventrally buff, distinctly emergent from buff vestiture of second segment. Antennal shaft long, about thrice length of club; club with nudum pale brown, buff proximally, darkening through pale orange to brown at apiculus, and nearly one-half length of club. **Wings.** Somewhat broad but not stubby or rounded. Forewing average length 13.6 mm [range 12–14 mm] (n = 15). Dorsal surface, stigma broad, microandroconial mass conspicuous, yellow; apical, middle, and lower black brush patches present and united, forming a continuous border around the microandroconial mass, poststigmatal patch broad and conspicuous. Inner edge fulvous subterminal spots usually offset distad from inner



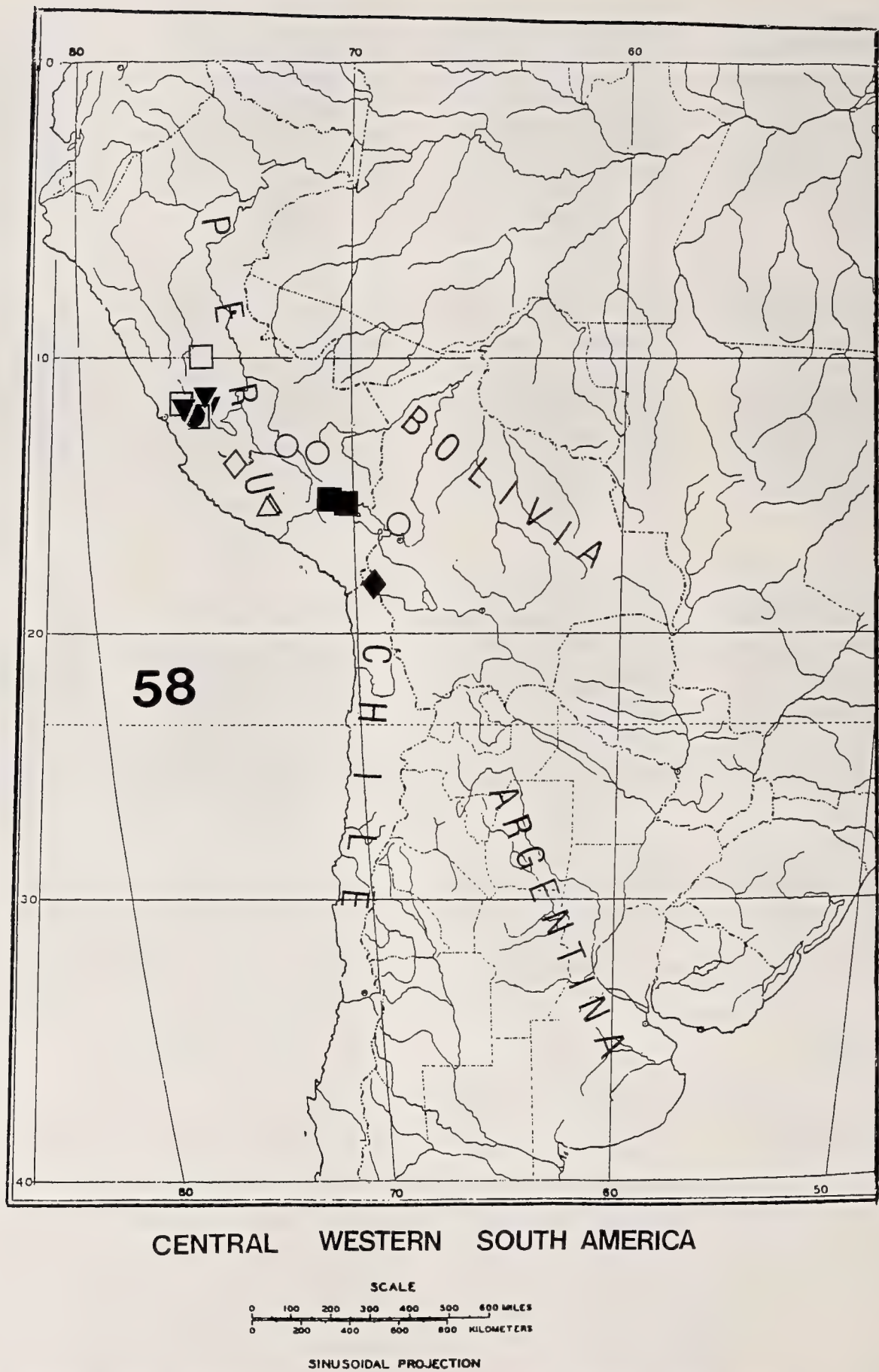


FIG. 58. Distribution map for eight species of *Hylephila*: Solid diamond = *H. herrerae*, new species; outlined triangles = *H. pseudoherrerae*, new species; outlined circles = *H. pallisteri*, new species; outlined squares = *H. blancasi*, new species; outlined diamond = *H. tentativa*, new species; solid circle = *H. shapiro*, new species; solid inverted triangles = *H. galera*; solid squares = *H. rossi*, new species.



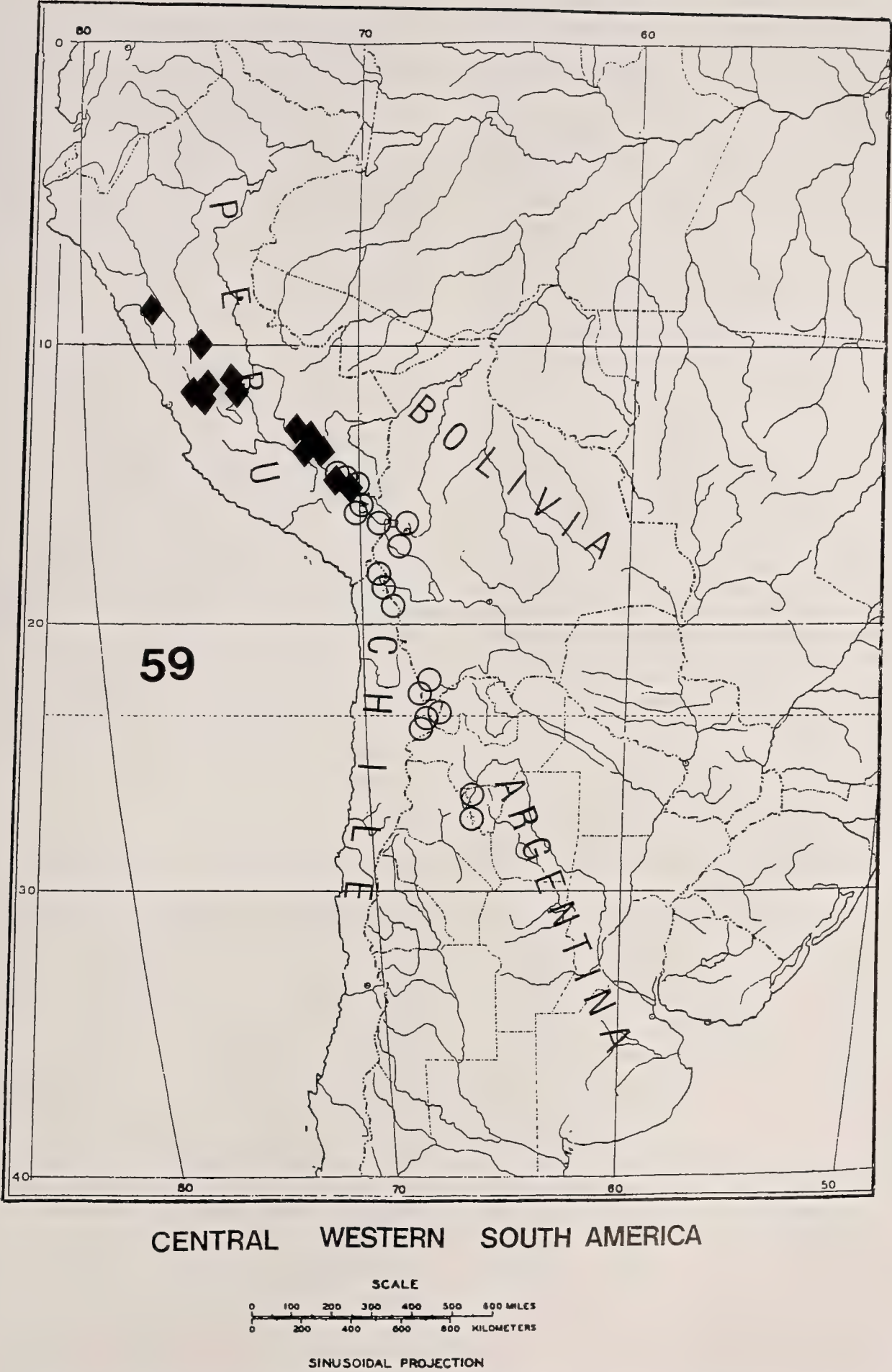


FIG. 59. Distribution map for two species of *Hylephila*: Outlined circles = *H. bouletti*; solid diamonds = *H. peruana*.



edge of postmedian macular band. Fulvous broadly warm-orange costad and basad in discal cell, usually extending well into fuscous border along veins, but occasionally border broad and scarcely indented (cf. Figs. 54 and 56). Fringes orange-fulvous. Below, stigma pockets broad; upper element spanning distance between origins of veins Cu1 and Cu2, diverging from discal cell cubitus vein much nearer to vein Cu2 than to vein Cu1 (Fig. 3d). Fulvous more extensive than above, veins R5 to M3 distally whitened. Fringe basally narrowly whitish, then fuscous, then terminally sullied fulvous. Hindwing above orange-fulvous as on forewing; vertex of chevron-shaped postmedian macular band in space M1–M3 usually conspicuously extended basad well into discal cell, and anterior arm present in space Rs–M1. Fringe orange fulvous. Below, fulvous paler than above; veins Rs to M3 whitened but not conspicuously so to naked eye; often a trace of an additional postmedian, elongate, black dash in upper part of space M1–M3. Fringe as on forewing. **Genitalia.** Eighth tergite lateral margin broadly concave mid-length but not distinctly emarginate just before caudal margin (Fig. 5e); terminal bristle-sockets enlarged and rounded just before caudal margin (Fig. 8). Valva (Fig. 25) in lateral view somewhat broad, ventral margin proximally convex, basal margin scarcely convex, dorsal and ventral margins caudally concave to caudal beak where knobs dorsad of horizontal cleft numerous; length basal margin greater than one and one-half times depth of valva. Penis proximally nearly straight or slightly curved dorsad, its length slightly exceeding length of genital capsule and nearly twice length of valva; titillators asymmetric, the left large, laterally compressed, thorn-like with a very broad base, the right much reduced, thorn-like, both sclerotically strapped to penis; cornuti asymmetric, one narrow, basally elongate, and minutely bidentate, the other basally broad and thorn-like, bidentate. Juxta with ventrocaudal clefts long, about one-half length of juxta; separated median floor reaching caudal margin of juxta. Uncus in dorsal view anteriorly rounded but posteriorly tapered (where minutely serrate) to broad caudal tip that greatly exceeds width of pectines, caudal cleft not exceeding pectines cephalad; pectines minute, length each half medially more than twice its breadth, distinctly tapered mesad anteriorly; the tines conspicuous, few; in lateral view uncus and pectines dorsally nearly flat. Gnathos in lateral view scarcely sclerotized, not divergent ventrally from uncus, scarcely exceeding pectines caudad.

**Female. Head.** As male but antennal shaft slightly shorter not quite thrice length of club. **Wings.** Orange to tawny fulvous above somewhat more restricted than in male owing to slightly broader fuscous border. Forewing average length 14 mm [range 13–15 mm] ( $n = 15$ ). Below as male, but forewing border usually greatly reduced in spaces M1–M2, M2–M3, and Cu2–2A. **Genitalia.** Eighth sternite in ventral view sclerotized, broad, more or less quadrangular (rounded ventrad in lateral view), with anterior margin straight or emarginate, its length in ventral view nearly or quite one-half its width. Apophysis anterioris somewhat produced cephalad of junction with lamella postvaginalis (Fig. 31). Lamella postvaginalis in ventral view narrowly united, each half produced ventrocephalad forming a slight anterior bulge, not nipple-like, medially not produced ventrally. Antrum dorsally sclerotized, with longitudinal fold, anterolaterally with increased sclerotization just before ductal constriction, ventrally membranous. Ductus bursae well sclerotized, in lateral view massive just beyond deep V-like ductal constriction, in ventral view left lateral pocket slightly produced.

**Types.** Lectotype ♂ (designated by Mielke 1993:622) in Senckenberg Museum, Frankfurt, Germany [SMF L 4068 (Genit. Präp. O. Mielke #532)]. PERÚ, Cuzco, 4500 m Fig. in Seitz (1923: Taf. 180 f, underside). Paralectotypes. Two specimens (designated by Mielke 1993:622) in Senckenberg Museum, Frankfurt, Germany. 1 ♀ SMF L

4069, Fig. in Seitz (1923: Taf. 180 f); PERÚ, Cuzco, 3500 m. 1 ♂ SMF L 4070, Fig. in Seitz (1923: Taf. 180 f). PERÚ, Cuzco, 4500 m.

**Diagnosis and discussion.** In the *boulleti* group of *Hylephila*, males of this species are arguably the specimens most easily identified without dissection, because of their conspicuous stigma with its yellow microandroconial mass, their extremely abbreviated uncal pectines (which can often be seen by merely gently brushing the abdominal tip from above), and their distribution in Perú: north and northwest of the department of Puno, where *H. peruana* occurs with several other members of the group (see maps, Figs. 58, 59).

This is the member of the *boulleti* group most commonly collected in Perú. I have seen 22 males and 20 females (18 males, 17 females dissected) from 18 localities in Perú. Flight records suggest perhaps four broods through the year with gaps appearing during March, June, September, and November–December.

Nine ova were dissected from three females (# ♀ 6377, # ♀ 6378, # ♀ 6379) prior to KOH treatment. Two eggs from # ♀ 6377 measured an average  $0.75 \times 0.63$  mm, and also a pair of eggs from # ♀ 6378 averaged  $0.85 \times 0.55$  mm. Five ova from # ♀ 6379 averaged  $0.83 \times 0.57$  mm, and the average of all nine ova is  $0.81 \times 0.57$  mm. The most common measurement for all the eggs was  $0.85 \times 0.55$  mm. The eggs were all very similar to eggs of *H. boulleti* including the very weak reticulation at  $100\times$  magnification, although the ova of this species proportionately do not seem to be as highly domed as are those of *H. boulleti*.

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## DEW-DRINKING BY MALE MONARCH BUTTERFLIES, *DANAUS PLEXIPPUS* (L.)

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**ABSTRACT.** We examined the early morning activity of overwintering monarch butterflies at a central coast California site during their period of “mass-mating” from mid-January to mid-March in 1998 and 1999. The first year of the study took place during El Niño weather when regional precipitation was approximately 50% greater than normal. The second year occurred during La Niña conditions with approximately 15% less precipitation than normal. On “rain-free” mornings many of the butterflies left aggregations and flew to an adjacent meadow where they landed on grass and drank from dew droplets. Males were much more likely to make morning meadow visits than females and such males had 6.7% higher body moisture than males that remained in the clusters. The rate of male meadow use increased seasonally both years and males were frequently seen attempting to mate following dew-drinking meadow visits. Early morning meadow-males resembled males attempting to mate in the morning more than males that were not mating, i.e., that remained in aggregations. Meadow-males were smaller, had relatively smaller dry-weight abdomen mass, and had more wing damage in addition to their greater moisture content. Variation in local solar radiation, wind speed and evapotranspiration during the previous 24 h was positively associated with early morning meadow use by both males and females. Male mating effort during the previous day was positively associated with early morning dew-drinking by males but not females. Three hypotheses regarding dew-drinking activity are considered. The results are consistent with two perspectives: dew drinking results from dehydrating activity such as courtship and spermatophore transfer during the previous day and/or it represents strategic male behavior in anticipation of “need” for future reproductive effort.

**Additional key words:** *Danaus plexippus*, dew-drinking, mating effort, dehydration, El Niño, La Niña.

Each fall monarch butterflies, *Danaus plexippus* (L.), migrate from an extensive late summer breeding range in North America to geographically restricted overwintering habitats (Brower & Malcolm 1991). Monarchs from eastern breeding populations overwinter in several mountainous areas dominated by Oyamel fir forests near Mexico City (Urquhart & Urquhart 1978, Brower 1985, Calvert & Brower 1986). Those originating west of the Rocky Mountains overwinter at wooded sites located along the Pacific Ocean between Bolinas, California and Ensenada, Mexico (Sakai & Calvert 1991, Lane 1993).

The general eco-region macroclimate where these sites are located, along with local topography and vegetation, provide microclimate conditions favorable for monarch overwintering (Brower et al. 1977, Calvert et al. 1982). Conditions thought to be important for overwintering include: (1) generally cool temperatures that minimize the rate of butterfly activity and rate of body fat utilization (Chaplin & Wells 1982, Masters et al. 1988, Alonso-Mejia et al. 1997), (2) a pattern of daily minimum temperature that reduces the likelihood of lethal freezing (Alonso-Mejia et al. 1997), (3) enough moisture to minimize desiccation (Calvert & Lawton 1993), (4) low wind velocity to minimize disruption and desiccation (Leong et al. 1991), and (5) exposure of butterflies in cluster formations to brief mosaics of direct solar radiation to enable periodic thermoregulatory basking (Calvert & Brower 1986, Frey et al. 1992).

Overwintering at Mexico sites occurs during the regional dry season but dehydrating conditions are reduced somewhat because these sites occur at high elevations (2400 to 3600 m) where cloud forests provide relatively high humidity and closed-canopy forests result in wind abatement (Calvert & Brower 1986).

Overwintering at California sites on the other hand occurs during the wet season, yet desiccation is a problem for monarchs. Moisture-producing storms decrease in frequency during February and March, occur sporadically, last for only brief periods and are often followed by many days of dry conditions. For example, during the wet 1998 El Niño event, on 58 days in January, February and March, moisture loss through evapotranspiration exceeded moisture gain from precipitation along the central coast of California (data source: California Department of Water Resources, California Irrigation Management Information System from weather stations located in Guadalupe, California). This potential for desiccation was even more pronounced during the dry 1999 La Niña winter.

An intense period of mating occurs between late January and early March at both Mexico and California overwintering sites during which males compete vigorously for mating opportunities (Hill et al. 1976, Tuskes & Brower 1978, Van Hook 1996, Frey et al. 1998). During a lengthy copulation the male transfers a spermatophore to his partner's reproductive tract, which may equal 10% of his body weight (Oberhauser 1988). Monarch spermatophores contain a small ampoule of spermatozoa along with various nutrients, but consists primarily of water (up to 93%) and females may use this “transferred” water for somatic maintenance (Oberhauser 1992, Pham 1997). At California overwintering sites mating could increase water deficit for males due to the high water content of spermatophores and the seasonal increase in evapotranspiration, solar radiation and temperature. Overwintering sites in Mexico and California are usually associated with a nearby source of water (Calvert & Brower 1986,



Leong 1990, Leong et al. 1991, Bell et al. 1993), but cause and effect relations of monarch hydration activity are not fully understood and hydration behavior has not been studied relative to male mating strategy.

At central coast sites in California monarchs remain relatively inactive throughout much of the overwintering period and spend most of the time in cluster formations (Hill et al. 1976, Tuskes & Brower 1978, Frey & Leong 1993, Frey et al. 1998). On relatively clear days when temperatures exceed the flight threshold many butterflies leave the aggregations and engage in a variety of activities. The majority of them land on sun-exposed canopy vegetation, while some nectar on the limited nearby flowering plants. At the North Beach Campground overwintering site located in Pismo Beach, California many of the butterflies that emerge from aggregations in the early morning fly to an adjacent meadow where they land on dew covered grass and appear to drink from dew droplets (pers. obs.). Small meadows regularly occur adjacent to western North America winter habitat or within the small gaps found in the stand of trees comprising the habitat.

In this study we examined the early morning activity of monarch butterflies at a central coast California overwintering site during the mass mating phase (January through March) of 1998 and 1999. Our objectives were to (1) describe the departure pattern of males and females as they left aggregations to visit a nearby meadow, (2) compare moisture content and morphology of males that visited the meadow to those that remained in aggregations or were engaged in other activities, (3) test whether weather variables from either the current day or from the previous day could explain any patterns from objectives 1 and 2 above, and (4) contrast meadow visiting activity and moisture content during two seasons differing greatly in regional moisture regimes.

#### MATERIALS AND METHODS

**The overwintering site.** This study was carried out in the southeast corner of North Beach Campground, Pismo Beach State Park, Pismo Beach, California. Throughout the study monarchs formed overwintering aggregations in a stand of trees dominated by blue gum eucalyptus (*Eucalyptus globulus* Labill.) along with scattered Monterey cypress (*Cupressus macrocarpa* Hartw.) and Monterey pine (*Pinus radiata* Don). A meadow 60 × 90 m, bordered on the west and north by trees, occurs in the southeast quarter of the site and is comprised primarily of rip-gut brome (*Bromus diandrus* Roth) and veldt grass (*Ehrharta calycina* Smith). The old-growth grass in the meadow was cut back to short stubble in early October during

both years. By the end of March 1998, the grass was 30 to 40 cm tall and uniformly covered most of the meadow. At the end of the overwintering period in the second year, i.e., March 1999, the grass was 20 to 30 cm tall.

**Counts of monarchs in the meadow.** Four uniformly spaced east-west transects were established across the meadow covering a total length of 240 m. On 17 days between 21 January 1998 and 10 March 1998 we visited the site in the early morning before ambient temperature exceeded the flight threshold (10–16°C; Masters et al. 1988, Alonso-Mejia et al. 1993). In 1999 we made 29 morning counts between 28 January and 26 March. On each of these days dew was present on the grass and other meadow vegetation. We slowly walked along each transect and counted the number of male and female monarchs located within 3 m on either side. A second count was done approximately 45 min after the first monarchs began flying out from the cluster trees and landing in the meadow.

**Macro and micro weather conditions.** Pismo Beach is located in a Mediterranean type ecoregion (Bailey 1978) and the study was conducted during what is usually the transition from the wet season to the dry season. The first year of the study occurred during El Niño weather (wetter than average) while the second season was considered a La Niña period (drier than average). For each day of the study we downloaded weather data from nearby California Irrigation Management Information System (CIMIS) recording stations located in Guadalupe and San Luis Obispo, California. The Pismo Beach overwintering site is located between these stations approximately 19 km from each station. The precipitation for January through March in 1998 and 1999 was approximately 50% greater (1998) and 15% less (1999) than the regional 30-year rainfall average. We restricted our observations to rain-free mornings because monarchs do not fly during overcast rainy periods. Year-to-year differences for all other weather variables on days of data collection were not as pronounced as the differences in the overall regional precipitation patterns reported above. In fact, evapotranspiration, solar radiation, and average wind speed recorded at the nearby CIMIS weather stations on days before morning meadow counts did not differ significantly between years (Table 1). We also recorded on-site air temperature in the meadow each day at the time when we observed the initial flight of a monarch from the cluster trees to the meadow and at the time of both of the counts of butterflies along the meadow transect. Initial flight temperature did not differ between years but



TABLE 1. Regional weather variables recorded during 1998 and 1999 on (a) the morning of meadow counts and (b) the day preceding meadow counts. Values are daily means  $\pm$  SE (standard error).

Variable <sup>1</sup>	1998	1999	P <sup>2</sup>
(a) Temperature of initial flight (°C)	11.2 $\pm$ 0.4	10.4 $\pm$ 0.3	0.106
Change in temperature (°C) <sup>3</sup>	2.2 $\pm$ 0.4	4.4 $\pm$ 0.4	< 0.001
(b) Evapotranspiration (mm)	1.9 $\pm$ 0.3	2.2 $\pm$ 0.2	0.459
Solar radiation (W m <sup>-2</sup> )	144 $\pm$ 17	162 $\pm$ 10	0.649
Wind velocity (ms <sup>-1</sup> )	2.7 $\pm$ 0.2	2.5 $\pm$ 0.1	0.344

<sup>1</sup> Evapotranspiration, solar radiation, and wind velocity values were down-loaded from CIMIS data bases for stations #52 in San Luis Obispo, California and #120 in Guadalupe, California maintained by the California Department of Water Resources.

<sup>2</sup> P-values are from Mann-Whitney tests.

<sup>3</sup> Change in temperature was recorded daily on-site as the difference in temperature of the initial morning flight from cluster trees versus the temperature during the second morning transect count approximately 45 minutes later.

mornings during 1999 warmed more quickly between transect counts than during 1998 (Table 1).

**Moisture content and condition of monarchs.** Males were captured weekly during 1998 from three different categories: (1) dew drinkers: males located in the meadow with their probosces extended into dew droplets on grass, (2) mating pairs: males that had just captured and coupled with a female near the meadow, (3) aggregating individuals: males captured with a net attached to a long-reach pole from the aggregations one hour after ambient temperature exceeded flight threshold. Males from the meadow and those mating were captured immediately following the second transect count of monarchs in the meadow. During 1999, males were captured in the meadow as described for category 1 above on the mornings of 23 February and 2 March. Males were captured from clusters as described for category 3 above on 20 February and 27 February 1999. Mating males were not sampled during 1999.

The number of wings that had membrane tears or portions missing were counted for each butterfly. We placed each male individually in a freezer proof zip-lock bag and stored them in an ice-chest until they were transported to our lab where they were frozen at  $-20^{\circ}\text{C}$ . These specimens were later weighed (wet weight) and then dehydrated in a drying oven at  $60^{\circ}\text{C}$  for 40 h. Individuals were weighed immediately on removal from the freezer to minimize bias due to accumulation of water that condenses on thawing specimens. Following dehydration their dried body weight was recorded and moisture content was estimated as the difference between wet and dry weight. Following dry weight measurement, the abdomen was severed

from the rest of the body and weighed separately. Dry weight of the abdomen relative to total dry body weight was used as an index of body condition or an approximate “fat-content” index.

**Estimation of male mating effort.** We estimated male mating effort in two ways. In the first technique we videotaped courtship responses of males to pinned monarch specimens positioned on platforms in areas of high mating activity. From late morning recording sessions (55 min duration) we summed the number of “visits” by males to the models as well as the number of times males landed on them and tried to couple with the models. For more details of this approach see Falco (1999). These values were converted to standard normal scores and used as an index of population-level male mating effort. The second technique involved late morning counts (approximately 1 h duration) of “ground pairs”, i.e., a male attempting to couple with a female, in the area where mating attempts frequently occurred. We followed the protocol of Frey (1999) and converted the number of observed attempts per minute to standard normal scores.

RESULTS

**Entry rates into the meadow.** A few monarchs were occasionally found in the meadow during count #1 before the beginning of morning flight activity. They were usually wet with dew, much more so than ones collected later in the day, and females were often found near males. We used an abdominal palpation technique (Van Hook 1999) and found that most of the females had a large detectable spermatophore present. This suggested that they had mated recently and possibly had spent part of the previous night in copula in the meadow rather than more typically being attached to males that perched in the canopy of nearby trees.

During the first year of the study the Pismo Beach monarch population declined from a peak abundance of 125,000 butterflies in late December 1997 to less than 1000 individuals by March 1998. During the second year the population declined from 100,000 monarchs in December 1998 to less than 1000 butterflies in March 1999. In both years the sex ratio became increasingly male biased seasonally which is a pattern previously reported for this site (Frey & Leong 1993, 1995, Frey et al. 1998). We computed an index of sex-specific increase in meadow abundance to adjust for the following factors: (1) differences in abundance and sex ratio pattern between years, (2) seasonal declines in abundance due to dispersal that began in January each year, and (3) slight day-to-day differences in the time interval between transect counts. This index was computed by dividing the number of new butterflies



TABLE 2. Number of male and female monarchs counted along transects in a meadow adjacent to overwintering cluster-trees, sex ratios, and per capita meadow entry rate for each sex. Results include 17 and 29 sampling dates for 1998 and 1999 respectively.

Year	Sex	First count	Second count	Meadow entry rate*
1998	Male	12.6 ± 2.4 (67%)	66.1 ± 12.3 (85%)	0.031 <sup>a</sup> ± 0.006
	Female	4.9 ± 1.1 (33%)	10.6 ± 1.9 (15%)	0.007 <sup>b</sup> ± 0.004
1999	Male	2.0 ± 0.6 (65%)	24.3 ± 2.3 (86%)	0.023 <sup>a</sup> ± 0.003
	Female	1.0 ± 0.3 (35%)	4.1 ± 0.7 (14%)	0.011 <sup>b</sup> ± 0.003

\* Individuals entering the meadow per min per 1000 males or females remaining in the overwintering area; values with the same letter subscript do not differ significantly ( $P > 0.05$ ) by unpaired Mann-Whitney  $U$ -tests. Counts are means ± SE.

arriving along the transects (i.e., second transect count minus initial count) by the time between counts and then dividing this value by the number of either males or females estimated to be present at the overwintering site on a particular date. Population abundance for each sex were available from MRR Jolly-Seber census estimates made weekly throughout both years of the study (DF unpublished data).

Meadow use rate adjusted for the factors above (i.e., per capita meadow entry) did not differ significantly between years for either sex (Table 2: males,  $P = 0.47$ ; females,  $P = 0.16$ ), but male rate was significantly greater than female rate for both years (Table 2: 1998,  $P < 0.01$ ; 1999,  $P < 0.01$ ). In 1998 male per capita entry rate into the meadow, averaged over the season, was 4.4 times greater than female rate and 2.1 times greater in 1999; by mid-morning the meadow was dominated by males.

**Body moisture, morphology and wing condition of males.** Meadow-captured males had greater moisture content than aggregating males during both years (Table 3:  $P < 0.01$ ) but year-to-year differences in moisture content were not significant (Table 3:  $P = 0.79$ ). During 1998, moisture content for both males collected from the meadow and those captured while mating early in the morning were significantly greater than cluster captured males (1-factor ANOVA & Fisher PLSD test,  $F = 13.57$ ,  $df = 2$ , 135,  $P < 0.01$ ). Males captured after spending less than 1 h in the meadow had approximately 6.7% greater moisture content than their counterparts collected from aggregations.

Males captured from dew-covered grass had significantly less dry weight body mass than cluster-captured males during both years (Table 3:  $P < 0.01$ ). However, a significant two-way interaction effect suggested that

TABLE 3. Moisture content, total dry body mass, and relative abdomen mass of male monarchs. Letters that differ within columns indicate significant differences ( $P < 0.05$ ) by pair-wise Mann-Whitney tests within years.

Year	Capture category	Sample size	Mean moisture content (%)	Mean dry body mass (mg)	Mean dry abdomen mass (%)
1998	Meadow	41	60 <sup>a</sup>	198 <sup>a</sup>	28 <sup>a</sup>
	Aggregations	47	56 <sup>b</sup>	243 <sup>b</sup>	30 <sup>b</sup>
	Mating	50	59 <sup>a</sup>	198 <sup>a</sup>	29 <sup>a</sup>
1999	Meadow	40	61 <sup>a</sup>	184 <sup>c</sup>	35 <sup>c</sup>
	Aggregations	41	57 <sup>b</sup>	253 <sup>d</sup>	43 <sup>d</sup>

the difference between dew-drinking vs. clustering male dry mass was more pronounced during 1999 (Table 3: year × category,  $F = 11.49$ ,  $df = 1$ , 165,  $P < 0.01$ ). Meadow-males had 18.5% and 27.3% less dry mass than their clustering counterparts in 1998 and 1999 respectively.

Difference in relative abdomen mass (i.e., dry abdomen mass divided by dry body mass) among the three categories was marginally significant for 1998 (Kruskal-Wallis  $H = 5.6$ ,  $P = 0.059$ ) but field captured males had significantly smaller abdomens than cluster-captured males (Table 3:  $P = 0.019$ ). Meadow-males had significantly smaller abdomens than cluster-males in 1999 (Table 3:  $P < 0.01$ ).

The dew drinking and mating males also had more damaged wings than males taken from clusters during the first year of the study (Two way contingency analysis; 3 groups × 5 damage categories;  $X^2 = 19.6$ ;  $df = 8$ ;  $P = 0.012$ ). Wing damage pattern was not surveyed during year 2.

**Factors affecting meadow use.** Neither the variation in the temperature of initial morning flights nor the variation in the increase in morning temperatures were significantly associated with meadow entry rates for either sex (Table 4). On the other hand, regional solar radiation received during the previous day was significantly associated with meadow entry rate for both sexes (Table 4: males,  $P < 0.01$ ; females,  $P < 0.05$ ). Evapotranspiration and wind velocity were marginal predictors of male meadow use but not female use. Days with dehydrating conditions (high solar radiation, evapotranspiration, and wind velocity) were followed the next morning by high meadow entry rate.

“Mating effort”, i.e., the standard normal scores of the methods outlined above, was significantly associated with male per capita meadow-use or dew-drinking recorded the following morning (Spearman  $Z = 1.95$ ;  $N = 20$ ,  $P = 0.05$ ). When mating activity was high, early morning use of the meadow was high on



TABLE 4. Results of Spearman correlation tests of weather variables as predictors of meadow entry rate during the 46 sampling dates of the 1998 and 1999 monarch mating seasons combined; (a) tests based on temperatures recorded on-site during the morning of meadow counts as predictor variables, (b) tests based on weather conditions during the day preceding meadow counts as predictors.

Predictor variable		Influence on male meadow entry rate		Influence on female meadow entry rate	
		Spearman "z"	P	Spearman "z"	P
(a)	Temperature of initial flights (°C)	-1.47	0.142	-0.87	0.386
	Change in temperature during morning (°C)	1.58	0.114	1.66	0.097
(b)	Evapotranspiration (mm)	1.92	0.055	1.41	0.159
	Solar radiation (W m <sup>-2</sup> )	2.85	0.004	2.34	0.019
	Wind velocity (m s <sup>-1</sup> )	1.74	0.082	0.561	0.576

the following day and vice versa. Female meadow-use was unrelated to the previous day's mating effort (Spearman Z = 0.19; N = 20, P = 0.85).

Female per capita use of the meadow did not change significantly during the course of the season (Spearman correlation; Z = 1.36, P = 0.18, N = 46). On the other hand, male per capita entry into the meadow increased significantly as the mass mating season progressed (Spearman correlation; Z = 2.80, P = 0.005, N = 46). Relatively greater proportions of the male population made early morning visits to the meadow later in the season.

DISCUSSION

Male and female monarchs flew from overnight roosting aggregations to a nearby meadow as morning temperature warmed above the flight threshold. Individuals of both sexes were observed drinking from dew droplets on grass blades, i.e., they had their probosces extended into the droplets for long periods of time. Males collected from the meadow had 6.7% greater moisture content than males collected from aggregations, which also suggests that they had been drinking. Leong et al. (1992) reported monarch water loss between 6% and 10% per day when held without water under lab conditions (19.1°C and 44.9% relative humidity). Males were much more likely to visit the meadow than females during the early morning when dew was available (Table 2).

Dew-drinking patterns were similar between the two years of this study even though the amount of precipitation differed greatly (Table 2). This pattern indicates that monarch moisture levels are closely regulated and influenced more by short-term events (e.g., the past 24 to 48 h) than over a longer term. In contrast, year-to-year differences in relative abdomen mass (Table 3, larger abdomens in 1999) probably reflected overall differences in temperature regimes between El Niño and La Niña seasons and the fact that fat reserves are used more rapidly under higher temperatures (Chaplin & Wells 1982). Average daily tem-

perature during January, February, and March of 1998 approximated the 30-average for the Pismo Beach area but were 4%, 3%, and 9% below normal respectively during 1999.

There are several reasons why water may be particularly important to males during the mass mating period at overwintering sites beyond a general need to reduce negative systemic physiological effects that may accompany desiccation. Three hypotheses regarding early morning dew-drinking are given in Table 5 along with specific testable predictions for each hypothesis. Early morning temperatures could influence flights from cluster trees (Table 5, Current Weather-hypothesis 1) because flight thresholds can vary slightly among individuals in overwintering populations (Masters et al. 1988, Anson Lui pers. com.). Alternatively, or in addition, weather associated with dehydration during the previous day could influence dew-drinking on the following morning (Table 5, Previous Day Weather-hypothesis 2). To test these first two hypotheses we combined data from both years of the study for the following three reasons: (1) per capita meadow entry rate did not differ between years for either sex (Table 2), (2) on-site temperature during the initial morning flights did not differ between years, and (3) the regional evapotranspiration, solar radiation, and wind velocity on days preceding our observations of dew-drinking did not differ between the two years (Table 1).

Neither temperature-related prediction of the "current weather constraint" hypothesis, i.e., Table 5-hypothesis 1, was borne out in this study (Table 2 & Table 4a). Early morning conditions, however, can influence meadow use since monarchs are constrained from flying at temperatures below approximately 10°C and they seldom fly under overcast conditions (pers. obs.). One of the two predictions of the "previous day weather" hypothesis, i.e., Table 5-hypothesis 2, was confirmed. Levels of solar radiation and other weather variables associated with dehydration on a given day were positively correlated with dew-drinking rate on



TABLE 5. Three hypotheses regarding monarch butterfly early morning dew-drinking.

Hypothesis	Description	Predictions
(1) Current weather constraint	Flight from overnight cluster aggregations is constrained by low temperatures (Masters et al. 1988), thus variation in morning temperature influences early morning meadow visits.	1. Meadow use should be greater on mornings that warm more quickly. 2. Male and female pattern should be similar
(2) Previous day weather	Weather conditions associated with dehydration (e.g., evapo-transpiration) during the previous day influence dew-drinking on the following morning.	1. Days with high levels of evapo-transpiration, wind velocity, and solar radiation should be followed by mornings with high levels of dew-drinking and vice versa. 2. Male and female pattern of dew use should be similar
(3) Previous day mating activity	High levels of mating activity increase dehydration among monarchs and should influence dew-drinking on the following morning.	1. Measures of mating effort at the population level should correlate with dew-drinking rate on the following morning. 2. Males should be more strongly affected than females. 3. Per capita dew-drinking rate should increase seasonally for males but not for females.

the following morning, but the effect was much more pronounced for males than females (Table 4b).

A third hypothesis that may account for the dew-drinking pattern reported here relates to the level of mating activity on the previous day (Table 5—hypothesis 3). Similar to other butterflies, monarch mating consists of several stages (Rutowski 1991). Initially males locate potential partners either by perching on sun-exposed vegetation and waiting for females to pass nearby or by patrolling the air space near roosting trees (Falco 1999). Both of these locating tactics expose males to direct sunlight, dry air, and high wind speeds. These conditions are more dehydrating than if they remained clustered. Early morning dew drinking by males and females may be a direct response to water deficit incurred primarily during mating effort on the previous day.

Water uptake by male monarchs may influence their reproductive success indirectly. The majority of females mate multiple times at California overwintering sites (Hill et al. 1976, Leong et al. 1995, Frey et al. 1998, Frey 1999). A pattern of sperm precedence exists so that sperm from the most recent mating fertilizes the majority of eggs (Karen Oberhauser pers. com.) and sperm can survive for several weeks (Oberhauser 1997). A male's reproductive success is probably a function of his partner's subsequent inter-mating interval. Females that receive relatively large spermatophores have longer inter-mating intervals (Oberhauser 1989) and are more likely to exhibit effective resistance to male mating attempts (Frey 1999). Early morning dew drinking may enable males to generate accessory fluids necessary to produce a relatively large spermatophore during a subsequent mating and thus indirectly reduce chances that his sperm will be displaced. It is possible that dew drinking in this case is

also strategic behavior rather than a simple response to water deficit. All three predictions of the "previous day mating activity" hypothesis, i.e., Table 5—hypothesis 3, were supported by our findings (see Results—Factors affecting meadow use).

Males that visited the meadow exhibited morphometric characters that were more similar to early morning mating-pool individuals than those captured later during the morning from clusters. Dew-drinking males had lower body weight (dry-mass), smaller abdomens, and higher wing damage (Table 3). Male monarchs attempting to mate differed similarly from clustering males at Mexico and California overwintering sites (Van Hook 1996, Frey et al. 1998, Oberhauser & Frey 1999). Both dew-drinking and mating males in our study had relatively high moisture content (Table 3). Sunny, drier, and windier days were followed by increased male dew drinking the next morning (Table 4). In addition per capita dew drinking increased seasonally for males (but not for females) and their per capita mating effort also has been found to increase seasonally at this site (Falco 1999, Frey 1999). This is an expected pattern if water "lost" by males, both from increased exposure to desiccation during mating attempts as well as during spermatophore transfer, was replenished by dew drinking. On the other hand, many of the meadow-visiting males attempted to capture females within minutes of drinking dew. This is consistent with the view that early-morning dew drinking is a strategic male activity with the potential to increase short-term reproductive success in the ways described above.

Male-biased sex ratios similar to those reported here for dew-drinking are described for puddling activity in other Lepidoptera (Adler 1982, Adler & Pearson 1982, Boggs & Jackson 1991, Sculley & Boggs 1996, Beck et



al. 1999; but see Scriber 1987). Puddling is often viewed as differential foraging, which either supplies ionic or nutrient resources needed by males (Arms et al. 1974) or is a means for males to acquire resources that they transfer to females during copulation (Sculley & Boggs 1996). Alternatively, or in addition, male biased puddling in Lepidoptera could provide moisture for reproductive activities, as well as, maintenance, as outlined above for monarchs. Monarchs also puddle at Mexico overwintering sites (pers. obs.) but puddling has not been reported for monarchs in western North America.

Nectaring from nearby flowering plants has been observed for monarchs during the mass mating phase at a Mexico overwintering site (Alonso-Mejia et al. 1997). Flower-visiting monarchs in Mexico were smaller (dry mass), had significantly less fat reserves and had relatively greater moisture levels than cluster-captured ones (58% vs. 54% respectively for moisture as a proportion of wet body weight; our calculations of data from Table 2 in Alonso-Mejia et al. 1997). The pattern for moisture content of these Mexico monarchs is similar to those from our dew-drinking study and indicates that nectaring can also provide monarchs with a source of water. Few nectar sources however occur near the Pismo overwintering habitat and monarchs are seldom observed nectaring during January and February (pers. obs.). Likewise, they seldom drink from open water that usually occurs in shaded areas of the habitat, suggesting that monarchs probably obtain most of their water from dew or water droplets.

Dew drinking by monarchs, like nectaring and puddling, may be "triggered" by a number of proximate-level factors and may provide water that is used in several functional contexts. Early morning dew drinking by monarchs seems to be a response to short-term dehydration as well as strategic behavior associated with male reproductive activity.

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## SIBLING RIVALRY IN FLORIDA: THE DISPLACEMENT OF *PYRGUS COMMUNIS* BY *PYRGUS ALBESCENS* (HESPERIIDAE)

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**ABSTRACT.** A total of 204 specimens were collected during a field survey of *Pyrgus* conducted in Florida during 1989–2001. Identification of males was based on genitalic examination. Males of *Pyrgus albescens* were recorded from 32 Florida counties. Males of *Pyrgus communis* were recorded from only 6 counties. Based on the results of this survey, as well as a review of 86 male specimens in public and private collections dating 1895–2001, it can be concluded that only *P. communis* originally occurred in Florida, but has recently been displaced by *P. albescens*. *Pyrgus albescens* was also found in Alabama and Georgia, and may be approaching South Carolina. Presented are details of the field survey, as well as a listing of all specimens used in this study. Also provided is information on habitats and hostplants of *P. communis* and *P. albescens* in Florida.

**Additional key words:** Alabama, distribution, drought, Georgia, habitats, hostplants.

Burns (2000) clarified the status of the sibling species *Pyrgus communis* (Grote) and *Pyrgus albescens* Plötz (common checkered skipper and white checkered skipper, respectively). There is no known reliable method to separate these species based on wing pattern, but male genitalia exhibit consistent differences in the shape of the distal end of the left valve (Burns 2000). As a result of this study, *P. albescens* was shown to be much more widespread than previously believed. This species was once thought to be limited to the southwestern United States and Mexico, but is now known to range eastward across the Gulf Coast states to Florida. The Florida distribution of *P. albescens* revealed by Burns (2000) is largely the result of a continuing survey of *Pyrgus* I have conducted since 1989.

In September 1989, I captured what appeared to be two male *P. communis* in Calhoun County of the Florida panhandle. Astonished by the scarcity of recent reports of *P. communis* in Florida, I decided to obtain voucher specimens whenever the species was encountered. In October of that year, I located a sizable population of *P. communis* in Pasco County of central Florida. Upon learning that John M. Burns (pers. com.) had found *P. albescens* in the extreme western Florida panhandle five years earlier, I decided to examine my specimens more closely. While the Pasco County individuals were clearly *P. communis*, the genitalia of those from Calhoun County were surprisingly consistent with *P. albescens*. Further intrigued, I continued to scrutinize the genitalia of all "*P. communis*" I obtained.

Nine additional male *P. albescens* were captured in late 1994 and early 1995 in Calhoun, Columbia, Hamilton, Jackson, and Liberty counties of northern Florida. Most of these specimens were forwarded to J. M. Burns who confirmed their identity. These records suggested that *P. albescens* was even more widely dis-

tributed in Florida. Since that time, I have continued to sample *Pyrgus* at every opportunity. As a result, I have found that *P. albescens* is expanding in Florida and has displaced *P. communis* in the process. Presented here are details of this survey, a review of historical specimens, and information on the habitat and hostplants of *P. albescens* in Florida.

### MATERIALS AND METHODS

Field surveys for *P. communis* and *P. albescens* were conducted in Florida during 1989–1992, 1994–1997, 1999–2001. They included trips expressly to locate *Pyrgus*, as well as opportunistic sampling during other research projects. Suitable habitats were identified via automobile and investigated on foot. Site visits were typically one hour or less in duration, depending upon site size (some were little more than narrow roadsides, others were multi-hectare pastures) and abundance of adults (fewer adults required more search time). If adults were not found, searches were discontinued after 30 minutes. When populations were located, males were randomly collected and the genitalia examined by brushing away the scales from the left valves under a stereomicroscope. Females were also obtained, but they cannot reliably be separated (Burns 2000). Most females were tentatively determined by association with identified males. The remaining females were not assigned to either species. Because females are inseparable, none were considered when evaluating the distributions of *P. albescens* and *P. communis* in Florida.

Also examined were Florida specimens deposited in various public and private collections. Male were determined through genitalic examination as follows: specimens in the National Museum of Natural History, American Museum of Natural History, and Florida State Collection of Arthropods were identified by J. M. Burns, specimens in The Natural History Museum (London) were identified by Kim Goodger; the single 1978 specimen in the Allyn Museum of Entomology was identified by J. Y. Miller; T. M. Neal and A. D.

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FIG. 1. Locations of male *Pyrgus* captures during the period 1895–2001, where circles represent the 1989–2001 field survey and triangles are specimens in public and private collections. Solid circles and triangles, *P. albescens*; open circles and triangles, *P. communis*; half-solid circles and triangle, both species. Solid circles outside Florida represent survey specimens of *P. albescens* from Houston Co., Alabama, and Seminole Co., Georgia (USNM).

Warren identified specimens in their personal collections; all other specimens were identified by J. V. Calhoun (JVC).

## RESULTS

The field survey yielded a total of 204 specimens, obtained from 45 locations in 33 Florida counties (Fig. 1, Table 1). Males of *P. albescens* ( $n = 138$ ) were recorded at 36 locations in 32 counties. Extreme collection dates range from 8 April–16 November. Males of *P. albescens* were also captured on 15 October 1995 near Grangeburg in Houston Co., Alabama ( $n = 1$ ) and near Riverturn in Seminole Co., Georgia ( $n = 3$ ). In contrast, males of *P. communis* ( $n = 15$ ) were only obtained from 6 locations in 6 Florida counties. Extreme collection dates range from 16 July–31 December. Females tentatively assigned to *P. albescens* ( $n = 31$ ) were recorded at 12 locations in 12 counties. Females tentatively assigned to *P. communis* ( $n = 8$ ) were recorded at 3 locations in 3 counties. Unassigned females ( $n = 12$ ) were recorded at 8 locations in 7 counties. One hundred and thirteen male and 11 female specimens collected between 1989 and 1999 were provided to J. M. Burns at the National Museum of Natural History (USNM), Washington, D.C. Most of the remaining specimens are deposited in my personal collection.

Due to the general apathy exhibited by lepidopterists toward anything resembling the “common” *P. com-*

*munis*, relatively few Florida specimens exist in public and private collections. Nonetheless, 86 male specimens from Florida were ultimately located (Table 2). The majority of these specimens represent *P. communis* ( $n = 56$ ), collected in 15 counties between 1895 and 1998. The remaining male specimens are *P. albescens* ( $n = 30$ ), more recently collected in 7 counties during the period 1976–2001.

At no time have both *P. albescens* and *P. communis* been encountered together at the same location in Florida. However, *P. oileus* (Linnaeus) shares many locations (and hostplants) with its congeners. Habitats for these species in Florida include vacant lots, weedy pastures, fallow cropland, farmyards, edges of cultivated fields, open roadsides and citrus groves. These habitats are generally characterized by low-growing vegetation and an abundance of nectar sources, interspersed with patches of bare ground. Favorite flowers of both species are mostly white and include *Bidens alba* (L.) DC (Asteraceae), *Phyla nodiflora* (L.) Greene (Verbenaceae), *Melilotus albus* Medik. (Fabaceae), *Richardia brasiliensis* Gomez (Rubiaceae) and *Sida* spp. (Malvaceae). In Jackson County, Florida, I observed *P. albescens* ovipositing on *Sida rhombifolia* L., which also serves as a host of *P. albescens* and *P. communis* in Texas (Kendall 1965, Neck 1996, Burns 2000), as well as *P. oileus* in Texas and Florida (Kendall 1976, Minno & Emmel 1993). In 1997 and 1999, Marc C. Minno reared *P. albescens* from larvae found on *S. rhombifolia* in Okaloosa and Brevard counties of Florida (adults det. by JVC). In Brevard County, I also found *P. albescens* in association with another, unidentified *Sida* species. It should be noted that some (or all) of the eight larval and two pupal specimens from Alachua County that Minno (1994) attributed to *P. communis* could actually represent *P. albescens* (no differences in the early stages of these species have yet been documented).

Although Smith et. al (1994) observed that *P. oileus* and *P. communis* are indistinguishable on the wing, males of *P. oileus* appear whiter in color and both sexes of this species have a more sluggish, bobbing flight. *Pyrgus oileus* also tends to frequent semi-shaded situations, whereas *P. communis* and *P. albescens* rarely stray from direct sunlight. Flight behavior of *P. communis* and *P. albescens* does not appear to differ. Both species fly rapidly near the ground and pause often to visit flowers. Males spend much time flying low circuitous routes in search of females and will investigate virtually any movement, including other male *Pyrgus*, grasshoppers, and even falling leaves. This pugnacious behavior can become frustrating to anyone attempting to approach resting males, especially if grasshoppers



TABLE 1. *Pyrgus albescens* and *P. communis* records documented in Florida during 1989–2001 field survey. AME, Allyn Museum of Entomology, JVC, John V. Calhoun; USNM, National Museum of Natural History.

Date	County	Nearest town/city	Specimens	Collection	Date	County	Nearest town/city	Specimens	Collection
1. <i>Pyrgus albescens</i> (males)					1.ix.90	Pasco	Dade City	2	USNM
4.viii.94	Columbia	Lake City	2	USNM	8.ix.90	Polk	Branchborough	2	USNM
4.viii.94	Hamilton	Jasper	1	JVC	30.ix.90	Pinellas	Tarpon Springs	2	USNM/JVC
8.iv.95	Calhoun	Altha	2	USNM	23.xi.90	Pasco	Dade City	2	USNM/AME
8.iv.95	Jackson	Oakdale	3	USNM	31.xii.90	Pasco	Dade City	2	USNM
8.iv.95	Liberty	Bristol	1	USNM	16.vii.94	Hernando	Brooksville	1	USNM
15.x.95	Calhoun	Altha	5	USNM	27.viii.95	Lake	Clermont	1	USNM
15.x.95	Jackson	Malone	1	USNM	Total			15	
15.x.95	Jackson	Oakdale	15	USNM	3. <i>P. albescens</i> (assigned females)				
30.x.95	Hamilton	Jasper	4	(lost in post)	4.viii.94	Columbia	Lake City	2	JVC
30.x.95	Suwannee	Pouchers Corner	1	(lost in post)	15.x.95	Jackson	Oakdale	6	USNM
5.ix.96	Jackson	Marianna	1	JVC	12.x.96	Jackson	Oakdale	3	JVC
12.x.96	Gadsden	Rosedale	1	USNM	13.x.96	Jackson	Oakdale	2	JVC
12.x.96	Jackson	Oakdale	4	JVC	3.ix.99	Alachua	Alachua	1	JVC
13.x.96	Jackson	Marianna	2	JVC	23.ix.99	Brevard	Scottsmoor	2	JVC
29.vi.97	Jackson	Greenwood	1	JVC	23.ix.99	Volusia	Scottsmoor	2	JVC
3.ix.99	Alachua	Alachua	2	USNM/JVC	1.x.99	Jefferson	Lamont	2	JVC
23.ix.99	Brevard	Scottsmoor	6	USNM	2.x.99	Santa Rosa	Harold	3	JVC
23.ix.99	Volusia	Scottsmoor	5	USNM	8.xi.00	Hillsborough	Piney Point	2	JVC
1.x.99	Gilchrist	Wilcox	7	USNM	16.ix.01	Lee	Alva	2	JVC
1.x.99	Levy	Chieffland	5	USNM	7.xi.01	Hernando	Rital	1	JVC
1.x.99	Jefferson	Lamont	5	USNM	7.xi.01	Polk	Kathleen	1	JVC
1.x.99	Holmes	Ponce de Leon	4	USNM	16.xi.01	Marion	Marion Oaks	2	JVC
2.x.99	Okaloosa	Cotton Bridge	7	USNM	Total			31	
2.x.99	Santa Rosa	Harold	4	USNM	4. <i>P. communis</i> (assigned females)				
2.x.99	Walton	Mossy Head	3	USNM	29.x.89	Pasco	Dade City	1	JVC
3.x.99	Bay	Saunders	5	USNM	1.ix.90	Pasco	Dade City	1	JVC
3.x.99	Franklin	Apalachicola	2	USNM	8.ix.90	Polk	Branchborough	1	JVC
3.x.99	Gulf	Wewahitchka	3	USNM	30.ix.90	Pinellas	Tarpon Springs	1	JVC
3.x.99	Washington	Orange Hill Corners	1	USNM	1.x.90	Pinellas	Tarpon Springs	2	JVC
11.x.99	Pasco	Dade City	12	USNM	23.xi.90	Pasco	Dade City	1	JVC
8.ix.00	Hillsborough	Gulf City	1	JVC	29.ix.91	Pinellas	Tarpon Springs	1	JVC
11.v.01	Lafayette	Grady	1	JVC	Total			8	
16.ix.01	Manatee	Piney Point	3	JVC	5. <i>Pyrgus</i> (unassigned females)				
16.ix.01	Lee	Alva	2	JVC	23.ix.90	Citrus	Chassahowitzka	1	USNM
20.ix.01	Pinellas	Tarpon Springs	7	JVC	27.viii.91	Pasco	Dade City	2	JVC
7.xi.01	Citrus	Bay Hill	1	JVC	30.viii.92	Pasco	Dade City	1	JVC
7.xi.01	Hernando	Rital	3	JVC	23.ix.92	Levy	Yankeetown	1	JVC
7.xi.01	Polk	Kathleen	1	JVC	8.ix.94	Pasco	Dade City	1	JVC
7.xi.01	Sumter	Nobleton	2	JVC	16.x.94	Volusia	Scottsborough	2	USNM/JVC
16.xi.01	Marion	Marion Oaks	2	JVC	13.xi.94	Hernando	Dixie	1	USNM
Total			138		14.x.95	Jefferson	Lamont	2	USNM
2. <i>P. communis</i> (males)					12.x.96	Gadsden	Chatahoochee	1	JVC
30.ix.89	Gadsden	Concord	1	USNM	Total			12	
29.x.89	Pasco	Dade City	2	USNM					

are flushed with every footstep. Males also perch on taller vegetation, permitting them to observe and examine passing objects easily. Adults of *P. albescens* and *P. oileus* have been seen roosting for the night on exposed herbaceous growth with wings tightly closed. This posture probably provides maximum solar exposure the following morning. *Pyrgus albescens* and *P.*

*communis* reach maximum abundance during September–November, when *Sida* hosts are plentiful. Although *P. albescens* and *P. communis* can be locally common where found, abundance can vary considerably between sites. Few adults were observed at many locations, accounting for the numerous single-specimen records documented during my survey.



## DISCUSSION

*Pyrgus communis* has been reported from 41 Florida counties, but many records are based on observations and literature where specimens are unavailable or lost (unpublished obs.). A number of literature reports are referable to *P. oileus*, especially females. For example, Grossbeck (1917) and Kimball (1965) listed *P. communis* specimens of W. T. Davis from Key West (Monroe Co.), Lakeland (Polk Co.) and Jacksonville (Duval Co.) that are now deposited in the Staten Island Institute of Arts and Sciences (det. by JVC). The two Key West specimens (16.ix.1913) are female *P. oileus*, confirming the suspicions of Minno and Emmel (1993). The two specimens from Lakeland (8.xi.1913) and Jacksonville (7.xi.1913) are likely female *P. communis*. Brewer (1982) listed *P. communis*, but not *P. oileus*, from Sanibel Island, Lee County. However, her local collection deposited at the Sanibel-Captiva Conservation Foundation contains just the opposite (*P. oileus*, but no *P. communis*).

*Pyrgus albescens* may have been present in Florida for some time, sustaining small, highly localized (i.e., easily overlooked) populations that suddenly expanded due to unknown reasons. Alternatively, the species spread eastward around the Gulf of Mexico into Florida where it rapidly dispersed across the panhandle, then southward through the peninsula. Historical specimens further support the more likely scenario that *P. albescens* has only recently invaded the state.

Based on specimens obtained during my field survey (Table 1), as well as those from other collections (Table 2), it can be concluded that only *P. communis* originally occurred in Florida. The first known male *P. albescens* specimen from Florida was collected in 1976 in Escambia County in the extreme western panhandle. All 54 male specimens collected during the 90 years prior to 1976 are *P. communis*. In 1984, J. M. Burns found additional *P. albescens* at another location in Escambia County. By 1992, this species had reached Gadsden County in the eastern panhandle. The last *P. communis* collected in the panhandle was in 1989. All 72 males collected after 1989 at 20 locations in 13 counties throughout the panhandle are *P. albescens*, thus this species has probably dominated that region since at least the late 1980's or early 1990's. By 1994, *P. albescens* had reached eastward in northern Florida to Columbia County and southward in the peninsula to Lake County. In 2001, *P. albescens* was found as far south as Lee and Okeechobee counties. The last confirmed *P. communis* recorded in Florida was in 1998 in Levy County of the northwestern peninsula. Since that time, all 72 males collected at 21 locations in 17 coun-

ties of the peninsula (including Levy Co.) represent *P. albescens*. The paucity of *P. communis* populations found during my field survey suggests that the expansion of *P. albescens* in Florida had begun prior to 1989.

The southward progression of *P. albescens* through peninsular Florida, and associated displacement of *P. communis*, is reflected by several records. In 1994 and 1995, I collected single males of *P. communis* (no *P. albescens*) in Hernando and Lake counties of the central peninsula. Also in 1994, D. R. Fine captured a single male *P. albescens* (no *P. communis*) at a more northern location in Lake County, suggesting this species was just invading that region. Evidence of direct displacement of *P. communis* by *P. albescens* was documented at three locations in northern and central Florida. In 1999, I captured only *P. albescens* in an agricultural field in Pasco County where only *P. communis* was recorded in 1989–1990. Likewise, in 2001, I found only *P. albescens* in a Pinellas County pasture where only *P. communis* had been collected in 1990. Unfortunately, dates of capture at these locations are nine or ten years apart, making the actual time of displacement difficult to determine. However, additional records from Levy County ostensibly limit displacement at one location to within six months.

On 4 October 1998, Ron Hirzel collected 2 male *P. communis*, but no *P. albescens*, at the crossroads town of Gulf Hammock in southern Levy County (Table 2). On 15 April 1999, and 20 March 2000, D. R. Fine captured 4 male *P. albescens*, but no *P. communis*, in the same area of Gulf Hammock. In 2001, Richard A. Anderson obtained another male *P. albescens* (no *P. communis*) at the same Gulf Hammock location. In October 1999, I found only *P. albescens* at a site in Levy County approximately 27 km north of Gulf Hammock (Table 1). Although *P. albescens* already occurred much further southward at that time, small peripheral populations of *P. communis* like that at Gulf Hammock may not have been as quickly impacted.

Although *P. communis* is considered rare in southern Florida, *P. albescens* may prove more successful at colonizing this region. The only known specimens of *P. communis* from southern Florida are a single old male from Punta Gorda (Charlotte County, ca. 1930) and another male collected in Miami (Miami-Dade County) in 1946 (Table II). The late John L. Heinrich (*in litt.* 30 November 1988) reported *P. communis* from Lee County, but only *P. oileus* are currently deposited in his collection at the Calusa Nature Center and Planetarium in Fort Myers, Florida. In 2001, I found *P. albescens*, but no *P. communis*, in Lee County where I had encountered only *P. oileus* between 1976



TABLE 2. Male *P. albescens* and *P. communis* specimens from Florida in public and private collections. AME, Allyn Museum of Entomology; AMNH, American Museum of Natural History; BMNH, The Natural History Museum (London); CMNH, Carnegie Museum of Natural History; DRF, David R. Fine; FSCA, Florida State Collection of Arthropods; JVC, John V. Calhoun; MCM, Marc C. Minno; RLB, Robert L. Beiriger, USNM, National Museum of Natural History.

Date	County	Location	Specimens	Collection	Date	County	Location	Specimens	Collection
1. <i>Pyrgus communis</i> (males)					15.viii.68	Liberty	Torrey State Park	1	FSCA
v.&vi.1895	Seminole	Sanford	1	BMNH	18.ix.68	Liberty	Sweetwater Creek	2	FSCA
19??	Alachua	Gainesville	2	FSCA	5.iv.69	Alachua	Gainesville	2	FSCA
18.iv.19??	Charlotte	Punta Gorda	1	USNM	6.iv.69	Alachua	Gainesville	1	FSCA
26.ix-2.x.14	Alachua	Gainesville	1	AMNH	15.viii.73	Gadsden	Quincy	1	TMN
4-8.x.14	Jefferson	Monticello	1	AMNH	19.viii.73	Gadsden	Quincy	3	TMN
?xi.17	Marion	Ocala	2	CMNH	20.x.73	Duval	Jacksonville	1	FSCA
≤1919	?	"Florida"	2	BMNH	25.vii.74	Alachua	Gainesville	1	TMN
<1939	?	"Florida"	1	BMNH	31.x.77	Duval	Jacksonville	2	FSCA
3.v.42	Alachua	Gainesville	1	FSCA	28.iv.78	Franklin	Apalachicola	1	AME
7.vi.43	Alachua	Gainesville	1	FSCA	13.vii.87	Lake	Sugarloaf Mtn.	1	MCM
11.vi.43	Alachua	Gainesville	1	FSCA	9.ii.96	Putnam	Caravelle Ranch		
17.vi.43	Alachua	Gainesville	1	FSCA			WMA	1	MCM
6.vii.43	Alachua	Gainesville	1	FSCA	4.x.98	Levy	Gulf Hammock	2	ADW
4.viii.43	Alachua	Gainesville	1	FSCA	Total			56	
25.iv.44	Alachua	Gainesville	1	FSCA	2. <i>P. albescens</i> (males)				
2.v.44	Alachua	Gainesville	1	FSCA	22.v.76	Escambia	Pensacola Beach	1	USNM
8.v.46	Miami-Dade	Miami	1	AME	7.ix.84	Escambia	Cantonment	12	USNM
28.iii.49	Escambia	Pensicola Nav. Air. Sta.	1	USNM	26.viii.92	Gadsden	SW of Quincy	1	RLB
					?vii.94	Lake	Paisley	1	DRF
24.ix.49	Escambia	Perdido Bay	1	USNM	5.x.97	Okaloosa	Blackwater Riv.		
4.vii.59	Duval	Jacksonville	1	FSCA			St. For.	1	MCM
23.viii.59	Duval	Jacksonville	1	FSCA	15.iv.99	Levy	Gulf Hammock	2	DRF
22.xi.60	Duval	Jacksonville	1	FSCA	14.x.99	Brevard	Moccasin Is. WMA	6	MCM
9.v.62	Clay	Orange Park	1	FSCA	20.iii.00	Levy	Gulf Hammock	2	DRF
31.viii.63	Duval	Jacksonville	2	FSCA	1.iv.01	Lake	Paisley	1	DRF
19.x.63	Duval	Jacksonville	5	FSCA	7.viii.01	Okeechobee	Hilolo	1	DRF
14.ii.64	Duval	Jacksonville	1	FSCA	2.ix.01	Levy	Gulf Hammock	2	JVC
20.x.64	Duval	Jacksonville	1	FSCA	Total			30	
20.x.64	Clay	Orange Park	1	FSCA					
1.i.68	Duval	Jacksonville	1	FSCA					

and 1987 (Calhoun 1987). Smith et. al (1994) sought *P. communis* in southern Florida without success, stating “the failure of this Nearctic butterfly to enter the ‘tropical’ zone of the peninsula is remarkable.” On 30 August 2001, 23 adults of the “common checkered skipper” were observed near Flamingo, at the very southern tip of Florida, within Everglades National Park (Miami-Dade County) (Linda & Buck Cooper pers. com.). On 13 November 2001, another individual was observed in extreme southwestern Florida within Fakahatchee Strand State Preserve in Collier County (R. L. Emmitt pers. com.). Future research may confirm the suspicion that these populations represent *P. albescens*, thus confirming its complete penetration of Florida.

Credible observations and photographs of “common checkered skippers” in Florida have become much more frequent within the past two years. It seems likely that these reports represent *P. albescens* and the species is successfully colonizing areas not previously occupied by *P. communis*. I personally encounter *P.*

*albescens* in many habitats where only *P. oileus* was formerly observed. *Pyrgus albescens* also appears to be spreading northward. On 4 June 2000, D. R. Fine collected two males and one suspected female of this species (det. by JVC) at Darien along the Altamaha River in McIntosh County of eastern Georgia. This record, along with my 1995 specimens of *P. albescens* from Houston County, Alabama and Seminole County Georgia, may show this species is expanding throughout the southeast and may reach South Carolina in the near future (or has already done so).

No other species of butterfly in Florida has so deftly displaced another. Recent invasions of Florida by *Urbanus dorantes* Stoll (Hesperiidae) and *Danaus eresimus* (Cramer) (Nymphalidae) are excellent examples of successful widespread colonization (Knudson 1974, Calhoun 1996). However, neither of these exotic species has noticeably impacted its resident congeners, *Urbanus proteus* (L.) (Hesperiidae) and *Danaus gilippus* (Cramer) (Nymphalidae). The reasons behind the



incursion of *P. albescens* into Florida are baffling, but changes in precipitation levels may offer an enticing explanation.

Tilden (1965) and subsequent authors (e.g., MacNeill 1975, Orsak 1978) associated *P. albescens* with hot, arid lowland climates. In Texas, Neck (1996) similarly associated *P. communis* with "cooler, moister northern habitats" and *P. albescens* with "warmer, drier, southern habitats." Although Florida can scarcely be described as "arid," much of the state experienced moderate to extreme drought during the last decade, especially in 1989–1990 and 1998–2000 (NCDC 2001). These conditions, more pronounced in the peninsula, continued into 2001. Drought has been defined as "a condition of moisture deficit sufficient to have an adverse effect on vegetation, animals, and man over a sizeable area" (Warwick 1975). While Burns (2000) doubted the strict affinity of *P. albescens* to drier climates, the rapid expansion of this species in Florida during the 1990's may, at least in part, be a consequence of these drought conditions. Burns and Kendall (1969) suspected humidity to be a limiting factor in the distributions of closely related *Pyrgus philetas* Edwards and *P. oileus* in southwestern North America.

*Pyrgus communis* and *P. albescens* do not appear to coexist at any location in Florida, but they do occur together in many areas of the southwestern United States (Tilden 1965, Austin 1986, Burns 2000). The expansion of each species in that region seems to be inhibited by the other species (Burns 2000). However, competitive pressures and other limiting factors may differ in the southeastern United States where *P. communis* may not have historically interacted with *P. albescens*. The dynamics of these species within regions of sympatry are obscure and unpredictable. Over time, *P. communis* may rebound in Florida. Shifts in dominance between these species at a single site in Arizona occurred over periods as short as 26 days (J. Burns pers. com.). It is also plausible that *P. albescens* was once abundant in the southeast during the more distant past, but *P. communis* reasserted its dominance until recently. Continued monitoring of *Pyrgus* may reveal more about the intriguing relationship between these sibling species and the factors responsible for this extraordinary displacement.

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IMMATURE STAGES OF *SAIS ROSALIA* (NYMPHALIDAE, ITHOMIINAE)

**Additional key words:** life-history, Mechanitini, Solanaceae.

The immature stages of butterflies in the subfamily Ithomiinae (Nymphalidae) are relatively well known for most genera, with good descriptions available in the literature (DeVries 1987, Brown & Freitas 1994 and references therein). However, information is scarce or absent for many small genera (such as *Roswellia*, *Eutresis*, *Athyrtis*, *Paititia*, *Aremfoxia*, *Vela-dyris*, *Velamysta*, *Dygoris*, and *Hypomenitis*), and still incomplete for most larger diversified genera (*Hyaliris*, *Hypothyris*, *Napeogenes*, *Hyposcada*, *Oleria*, *Ithomia*, *Pteronymia*, *Greta*, *Hypoleria*). In the tribe Mechanitini, there is adequate information for most species and all genera (Brown & Freitas 1994), except *Forbestra* (larva briefly described in Drummond 1976) and *Sais* (minimal information on the egg and larva in Table 1 and Fig. 2 of Brown & Freitas 1994, from rearing in Goiânia, Goiás, Brazil, in 1968). In this paper, all immature stages of *Sais rosalia* (Cramer, 1779) are described and illustrated.

*Sais rosalia* (near subspecies *rosalinde* Weymer, 1890 = *paraensis* Haensch, 1905, see Lamas 1994) was studied on banks and islands of the Teles Pires River, north of Alta Floresta, state of Mato Grosso, Brazil, in February and June 2000. On the latter visit, many eggs and larvae were collected on a solanaceous vine, probably of the genus *Lycianthes* (very similar to the host recorded in Goiânia; a live plant has been kept to await flowering). Additional eggs ( $n = 19$ ) were also obtained from a wild caught female kept in a plastic bag with the host plant. The larvae were kept with leaves of the host plant in plastic boxes that were cleaned daily. Egg size was measured as height and width; and the larval head capsule size as the distance between the most external ocelli (as in Freitas 1991, 1993); all capsules were retained for confirmation of growth stages. Adults, preserved larvae, capsules, and pupal skins are in the collection of the first author.

About 20 eggs and four first instars were collected in the field on several food plant individuals growing near the riverbanks in sunny places. The plants varied from 50 cm to 2 m high, and had small soft leaves. The isolated eggs and larvae were found on the underside of mature leaves. Females were observed ovipositing in the late afternoon, from 1500 to 1800 h. After inspecting the plant, the female landed on the upper side of a mature leaf and curved the abdomen to lay an isolated egg on the underside. After hatching, caterpillars ate part of the eggshell, and later began to eat the leaves,

chewing small holes in the blade. Although solitary, larvae were not cannibalistic; several instars could be reared together without losses. The caterpillars rested in a J-shaped position on the underside of the leaves. When disturbed, caterpillars dropped off the leaf, suspending themselves by silk threads.

**Egg** (Fig. 1a). White, elongated, slightly pointed at the apex, with 15–18 longitudinal ridges and 9–12 transverse ridges (similar to that described in Brown & Freitas 1994). Duration 3–4 days.

**Larvae. First instar.** White, turning green after first meal; legs, prolegs and anal plate black. Head black; average width 0.48 mm ( $SD = 0.03$ ,  $n = 11$ ). In dorsal view, the lateral tubercles (present in all instars) could be observed easily as small rounded projections on each abdominal segment. Maximum length 4 mm. Duration 2–3 days. **Second and third instars.** Dark green to leaden gray, with a white collar on the prothorax and a lateral series of short yellow tubercles along the abdomen; legs, prolegs and anal plate pale. Head black; average width (second instar) 0.75 mm ( $SD = 0.03$ ,  $n = 12$ ), (third) 1.19 mm ( $SD = 0.04$ ,  $n = 12$ ). Maximum length 8 mm (second) or 13 mm (third instar). Duration 3 days (second) or 8–9 days (third). **Fourth (final) instar** (Fig. 1b, c). Dorsum dark gray, ventral region pale gray, with a white collar on the prothorax and a lateral series of short yellow tubercles (tubercles on A1, A2, A7 and A8 more developed); legs and prolegs dark. Head black or rarely brown; average width 1.74 mm ( $SD = 0.04$ ,  $n = 10$ ). Maximum length 25 mm. Duration 5–6 days. The pre-pupa loses the contrasting color-pattern and becomes reddish, adopting an arched configuration (Fig. 1d).

**Pupa** (Fig. 1e–g). Elongated, slightly arched ventrally (about 60°) between the second and third abdominal segments, beige with a general gold reflection and black stripes on the wing cases (rarely dark with reduced reflective areas); cremaster red. Ocular caps short and pointed. Length 15 mm. Duration 13 days ( $n = 12$ ).

The immature stages of *Sais rosalia* are similar to those of other Mechanitini, including egg shape and size, number of longitudinal and transverse ridges, a lateral series of tubercles on the abdominal segments of the larvae, and the pupa elongated, slightly arched and reflective (Motta 1989, Brown & Freitas 1994). Contrary to *Mechanitis*, which has long pointed lateral tubercles, the larva of *Sais* bears short lateral tubercles, a feature shared with *Thyridia*, *Forbestra* and *Scada* (Brown & Freitas 1994). Perhaps the most interesting feature in the life history of the studied population of *Sais rosalia* is that there were only four larval stadia. All known ithomiine larvae have at least five instars (six instars were observed once in *Placidina*, AVLFPers. obs.), with the exception of *Tellervo zoilus* (Fabricius, 1775), also with four instars (Ackery 1987:272, with A. G. Orr); this Australian species has been placed in a separate subfamily by some authors (Ackery 1987).

Only four instars were also observed in 12 larvae of *Sais rosalia brasiliensis* (reared to pupae on the Teles



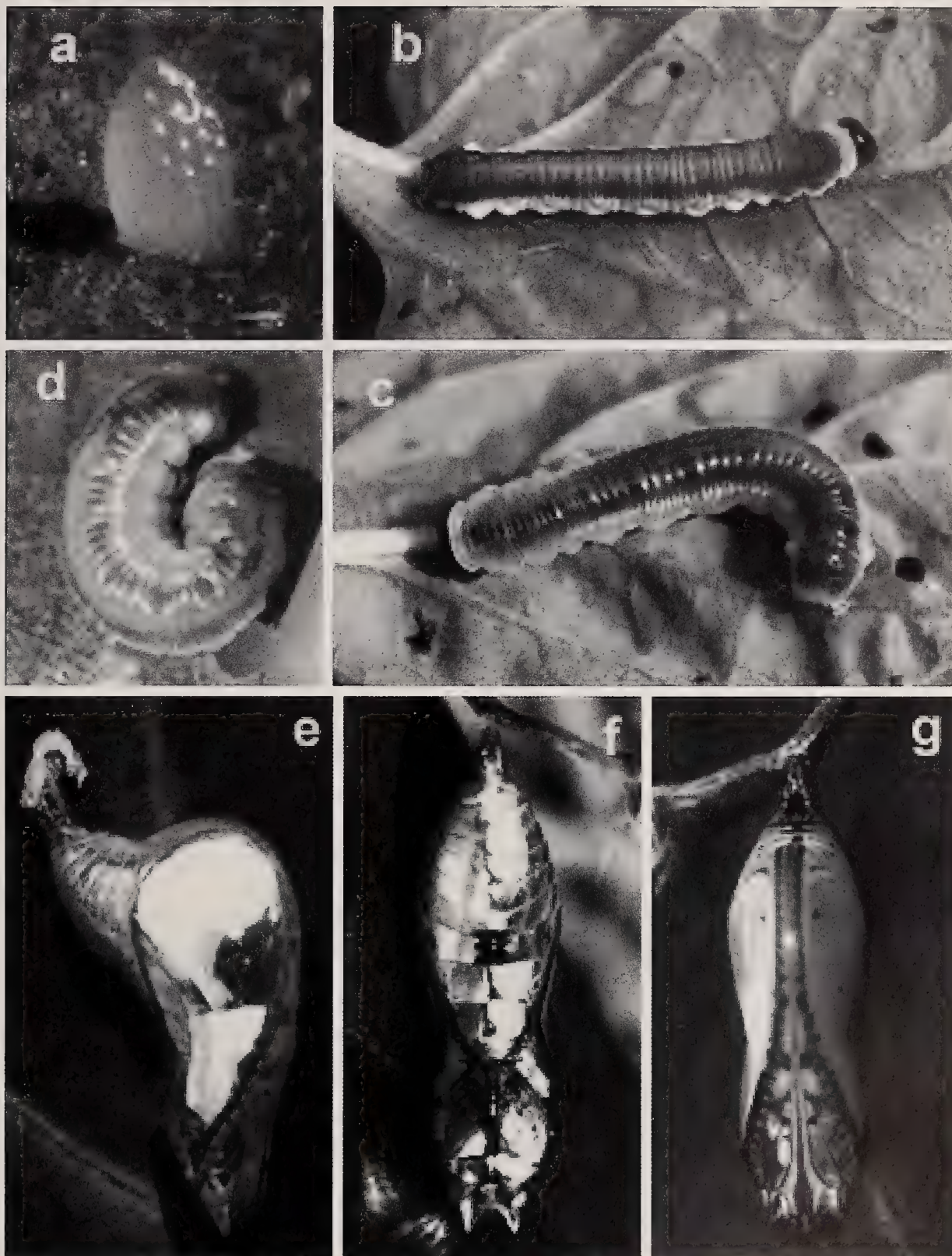


FIG. 1. Immature stages of *Sais rosalia*; **a**, egg; **b**, **c**, fourth (final) instar; **d**, pre-pupa; **e–g**, pupa (**e**, lateral; **f**, dorsal; **g**, ventral).

Pires plant) from 17 eggs of a single female captured on 28 November 2001 in the broad floodable gallery forests of the Rio do Peixe (21°36'S, 51°42'W, 1400 km south of the Teles Pires site, near Presidente Epitácio in extreme western São Paulo State). The recovered head capsules from larvae reared in 2001 show four widely separate width ranges: (1) 0.48–0.51

mm (N = 7), (2) 0.74–0.77 mm (N = 5), (3) 1.15–1.24 mm (N = 10, and (4) 1.72–1.96 mm (N = 8). All other aspects of larval coloration, instar duration, morphology and behavior were identical to the Teles Pires population.

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#### MATINGS WITHOUT SPERMATOPHORE TRANSFER AND WITH TRANSFER OF TWO SPERMATOPHORES IN *CALLOPHRYS XAMI* (LYCAENIDAE)

**Additional key words:** spermatophore production, copulation, sexual selection.

In Lepidoptera, males normally transfer one spermatophore during copulation (Drummond 1984). However, some studies indicate that in some matings no spermatophore is transferred (although this does not necessarily mean that the female is not inseminated; Drummond 1984). There are several possible explanations for this fact: (a) exhaustion of substances necessary for building spermatophores as a result of frequent mating (Drummond 1984); (b) male or female disabilities, such as deformations in the genitalia or in the reproductive tract resulting from disease or defective development; or (c) mate choice (rejection) after initiation of copulation by females (i.e., females somehow inhibit or prevent the transfer of spermatophores by certain males; Eberhard 1996) or by males (i.e., males avoid to transfer spermatophores to certain females). Mate rejection could be achieved by interrupting copulations before successful spermatophore transfer; in this case copulations are expected to be of short duration (Cordero 1993).

On the other hand, it has been found that sometimes males transfer more than one spermatophore in one copulation (Drummond 1984). This type of mating may be a male adaptation to sperm competition if the transfer of multiple spermatophores decreases female recep-

tivity during a longer period (in several species there is a negative correlation between female receptivity and the degree of distention of the corpus bursa) (Drummond 1984) or if permits the transfer of more sperm (for example, if spermatophores can contain only a certain maximum amount of sperm). However, the transfer of multiple spermatophores may be disadvantageous for many species, since the last spermatophore needs to be at least partially digested before re-mating because sperm migration to the spermatheca requires proper alignment of the spermatophore tube with the ductus seminalis and this alignment is more difficult in the presence of another spermatophore (Drummond 1984, Simmons & Siva-Jothy 1998). Thus, an alternative hypothesis is that the transfer of more than one spermatophore in one copulation is result of a male disability.

The multiplicity of explanations, and the theoretical relevance of many of them, indicates that to report matings in which no spermatophore is transferred and in which multiple spermatophores are transferred, as well as its possible causes, is important. During the course of three laboratory experiments on spermatophore production by males of the lycaenid butterfly *Callophrys xami* (Reakirt) (Cordero 1998), in which I observed 199



copulations, I recorded five copulations in which no spermatophore was transferred and four in which more than one spermatophore was deposited in the female corpus bursa. I report these observations in Table 1.

My observations suggest two possible causes of failure in spermatophore transfer. First, three of the four timed copulations lasted less (between ~7 and 15 min) than the average duration ( $\pm$ standard error) of first copulations of the day recorded in the field ( $32.3 \pm 4.9$  min; Cordero 1993) or in the laboratory ( $26.2 \pm 7.1$  min,  $32.9 \pm 9.8$  min and  $35.9 \pm 10.2$  min, considering each experiment separately; Cordero 1998), suggesting possible “interrupted copulations” (Cordero 1993). However, only in one case I observed the female behavior associated with such copulations. I have discussed the possibility that mate choice (by females or males) after mating began may be the cause of interrupted copulations (Cordero 1993). Second, female deformation of the ductus bursa and corpus bursa may have precluded the transfer of a spermatophore in case D (Table 1). Lifelong male disabilities may be discarded in all cases since the virgin male (case A) transferred one spermatophore in a posterior copulation, and the four previously mated males (cases B–E) had transferred one spermatophore in a previous mating and two of them in subsequent matings (Table 1). Although the possibility of male exhaustion of substances necessary for building a spermatophore cannot be discarded in the case of the male that mated twice in a day (case C), we have observed several second matings of the day and in all cases one spermatophore was transferred. From my observations, I cannot suggest possible causes for the cases in which two spermatophores were transferred during one copulation.

It is unlikely that the “abnormal” matings reported in Table 1 are purely a product of laboratory conditions. Experimental matings were performed in cylindrical mesh cloth cages (58 cm height and 26 cm diameter) hung outdoors in the natural habitat of *C. xami*, by individuals born in captivity. These conditions are artificial because territorial behavior (matings in the field are always performed by territorial males; Cordero & Soberón 1990, Cordero et al. 2000) and the initial aerial components of courtship (Cordero 1993) were prevented by the experimental method. However, in captivity all the non-aerial phases of courtship and copulation itself are, as far as I can tell, similar to those of occurring in the wild (Cordero 1993). Furthermore, the duration of matings in captivity and in the wild was very similar (see previous paragraph). Finally, the 190 experimental “normal” matings in which one spermatophore was transferred and the nine “ab-

TABLE 1. Male mating status previous to relevant copulation and mating duration (MD) in which no spermatophore was transferred and in which two spermatophores were transferred by male *Calolophrys xami*.

Male mating status	MD (min)	Comments
Copulation without spermatophore transfer (n = 5)		
A. Virgin	15	We tried to re-mate this male the same day without success; the next day he mated (31 min) and transferred two spermatophores (see case G); in a third mating he transferred one spermatophore
B. Mated once	10	Previous mating seven days before; male transferred one spermatophore in his first mating
C. Mated once	?	Previous mating the same day; male transferred one spermatophore in his first and in three subsequent matings
D. Mated once	~7	During four min the female was moving as in the “interrupted copulations” reported in Cordero (1993); this male mated the previous day during 20 min and transferred an spermatophore
E. Mated once	38	The female had deformed ductus bursa and corpus bursa; this male transferred an spermatophore in his first (two days before) and in a subsequent mating
Copulation with transfer of two spermatophores (n = 4)		
F. Virgin (n = 3) ~18, ~25, ?		These males transferred an spermatophore in their two, two and four posterior matings, respectively
G. Mated once	31	Male of case A

normal” copulations occurred under apparently similar conditions (in fact, all “abnormal” copulations occurred in days in which “normal” matings were also observed).

Although matings without spermatophore transfer and matings in which more than one spermatophore is transferred may be adaptive for males or females, they have negative effects on the fitness of at least one of the sexes (see above). The strength of the selective pressures exerted by the causes of these types of copulations is correlated with the frequency of such copulations. The nine “abnormal” copulations reported in Table 1 correspond to 4.5% of all copulations observed during the three experiments (n = 199); and the eight males involved correspond to 10.5% of all experimental males (n = 76).

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PAPILIO DEMOLEUS (PAPILIONIDAE) IN BORNEO AND BALI

**Additional key words:** Malaysia, Indonesia, Malay Archipelago, invasion, deforestation.

*Papilio demoleus* L. is widely distributed in the tropical and subtropical regions of Asian continent, Australia, and the islands of Taiwan, Hainan, New Guinea, and Lesser Sunda Islands (Sumba, Flores and Alor), but it had been lacking in Sumatra, Java, Borneo, the Philippines, and the Moluccas until its recent invasion of these islands (Corbet & Pendlebury 1978, 1992). Sumatra received ssp. *malayanus* Wallace from the Malay Peninsula and the Philippines ssp. *libanius* Fruhstorfer from Taiwan in the 1960–70's (Jumalon 1968, Hiura 1973, Miyata 1973, Tsukada & Nishiyama 1980). These two subspecies can be easily discriminated based on the wing markings; Fruhstorfer (1908), in his description of ssp. *libanius*, stated that the Taiwanese specimens appear darker than the nominate subspecies specimens from “Tonkin.” The dark appearance of ssp. *libanius* is mainly due to the fact that the yellow spots in spaces 1a and 1b of forewing upper surface are always narrow, whereas these spots are always very broad in ssp. *malayanus*, though as was not mentioned in the Wallace's (1865) description of the subspecies (Figs. 1–4).

The Malay subspecies was confirmed to have established its population in Java, supposedly having invaded from Sumatra during late 1980's (Kato 1989, Matsumoto & Noerdjito 1996). The species has also been found from Borneo. Otsuka (1988) illustrated a male and a female specimen of *P. demoleus* from Keningau, Sabah, without mentioning that the records were new in Borneo. Although Otsuka (1988) did not identify the subspecies, the illustrated specimens exhibited typical characters of ssp. *libanius*. Ishii (1987,

1991) identified *P. d. libanius* from Sandakan, Sabah, and he mentioned (Ishii 1991) that he saw only a few individuals of this species in 1981, while he found many individuals of the same species in 1983, and suggested that the Taiwanese subspecies may have invaded from the Philippines during the early 1980's.

TABLE 1. Year of first record and presumed origin of the *Papilio demoleus* populations recently established in the Southeast Asian Islands.

Island	Year of first record	Presumed origin	Literature
Luzon	1967*	Taiwan	Jumalon (1968)
Cebu	1968?	Taiwan	Hiura (1973)
Leyte	1968?	Taiwan	Hiura (1973)
Palawan	1969	Taiwan	Hiura (1973)
Negros	1969?	Taiwan	Miyata (1973)
Mindanao	1969	Taiwan	Miyata (1973)
Mindoro	1971	Taiwan	Hiura (1973)
Talau	Unknown**	Taiwan	Tsukada & Nishiyama (1980)
Sangihe	Unknown**	Taiwan	Tsukada & Nishiyama (1980)
Sula	Unknown**	Taiwan	Tsukada & Nishiyama (1980)
Borneo	1983	Taiwan	Ishii (1987)
	1996	Malay Peninsula	This study
Sumatra	Unknown**	Malay Peninsula	Tsukada & Nishiyama (1980)
Java	1988*	Malay Peninsula	Kato (1989)
Bali	1991	Malay Peninsula	This study

\* Except old sporadic records which are unrelated to the present population (see Jumalon 1968, Moonen 1991 for further details).  
\*\* Tsukada & Nishiyama (1980) first stated occurrence of the species in Sumatra without indicating earliest collection data.





FIGS. 1-4. *Papilio demoleus* collected in Borneo and Bali: **1**, a male with characters of ssp. *malayanus* (Bukit Soeharto, East Kalimantan, 16 Nov. 1998); **2**, a male with characters of ssp. *libanius* (Bukit Soeharto, East Kalimantan, 23 Nov. 1998); **3**, a female with intermediate characters between ssp. *malayanus* and ssp. *libanius* (Tawau, Sabah, 11 June 1996); **4**, male *P. d. malayanus* (Nusa Dua, Bali, 17 February 1991).







(NIAES), Japan. These specimens had typical characters of ssp. *malayanus* (Fig. 4). To my knowledge, this is the first record of the species from Bali. Although there has been no more information of this species in Bali, it seems likely that the species is established there.

**Factors favoring spread of *P. demoleus*.** *Papilio demoleus* frequents in and around villages and urban areas. It is originally a species of monsoon regions and prefers open habitats to thick shadowy rain forests as used to dominate in Sumatra, Java, Bali, Borneo and the islands of the Philippines. Hiura (1973) suggested that this habitat preference is the reason why this species had never occurred in the rain forest regions in Sunda Land and the Philippines before, while recent large scale deforestation in the Philippines prepared suitable habitats for the species. I share the same view with him and believe that the same logic applies to the recent establishment of the *P. demoleus* populations in Sumatra and Borneo. In densely human populated Java and Bali, forests have been exploited earlier and suitable habitats for *P. demoleus* have long been prevalent. However, Java and Bali had been far derived from the nearest *P. demoleus* population, until effects of extensive logging and consequent human activities, e.g., fire, shifting cultivation, illegal settlements, cattle breeding, etc. in the forests (or ex-forests) became conspicuous in Sumatra in the 1960–70's. After this stage, Sumatra played a role of stepping stone for *P. d. malayanus* to invade into Java, and then Java played a similar role between Sumatra and Bali. The occurrence of *P. demoleus* in Bali in 1991 indicates that the invasion into Bali took place almost immediately after its establishment in Java. The Malay subspecies in Borneo could have invaded either from Sumatra or Java, or directly from Malay Peninsula (Fig. 5).

Then, a question arises; why the Australian subspecies (i.e., ssp. *sthenelus* Macleay of Australia and Sumba, ssp. *sthenelinus* Rothschild of Flores and Alor and ssp. *novoguineensis* Rothschild of New Guinea) would not spread? Food plant availability could be the factor favoring spread of the Asian subspecies, not the Australian subspecies. The Asian subspecies feed on oranges, *Citrus hystrix* DC., *C. aurantifolia* Swingle, *C. amblyocarpa* Ochse, etc. (Rutaceae; Corbet & Pendlebury 1992, Matsumoto & Noerdjito 1996) which are very commonly planted either as a crop or an ornament in towns, villages and illegal settlements in the forest areas. The Australian subspecies feed on wild leguminous plants of the genus *Psoralea* L.: i.e., *P. tenax* Lindl., *P. patens* Lindl., *P. cinerea* Lindl., *P. leucantha* F. Muell. and *P. pustulata* F. Muell. in Australia (Common & Waterhouse 1981) and *P. badocana*

Benth. in Papua New Guinea (Parsons 1999) (no food plant record available for the Lesser Sunda populations). Although *Psoralea* plants occur in the Sunda Islands (Bentham & Mueller 1967), there has been no evidence to indicate increase of these plants favored by recent environmental changes. The *Citrus* feeding Asian subspecies, on the other hand, are now expanding its range in the Malay Archipelago, being favored by increase of habitats with artificially planted *Citrus* hosts.

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## NOTES ON THE NEVADA BUCK MOTH, *HEMILEUCA NEVADENSIS* (SATURNIIDAE) IN SOUTHERN MANITOBA

**Additional key words:** Tachinidae, *Leschenaultia*, bur oak, Hemileucinae, *Apoecilus*.

Observations on the Nevada buck moth, *Hemileuca nevadensis* Stretch, in southern Manitoba are reported, along with information regarding new predator and parasitoid associations for this species, as well as a new host plant association. In Manitoba, *H. nevadensis* has been collected in widely separated localities like Aweme, Selkirk, Victoria Beach, and Winnipeg. Limited collection records indicate that the flight period in southern Manitoba begins in late August or early September. Adults are day flying, with mating and ovipositing occurring the same day (Tuskes et al. 1996). Eggs are laid in rings around twigs of willows (*Salix* spp.) and trembling aspen (*Populus tremuloides* Michaux). Eggs overwinter and hatch early in the spring, almost synchronously with leaf flush. During the first three instars larvae are black in coloration and are gregarious (Tuskes et al. 1996). In southern Manitoba, pupation occurs in mid-summer (late-June to mid-July). Adults eclose approximately two months later. Little else is known about the biology of this species in southern Manitoba.

In early June 1998, several students and faculty from the University of Manitoba Department of Entomology traveled to the Manitoba Tall Grass Prairie Preserve located approximately 10 km east of the town of Roseau River, Manitoba (49.06°N, 96.7°W), (Fig. 1). This locality is characterized as having an abundance of grasses, willows and poplars. Predominant grasses include big bluestem, *Andropogon gerardii* Vitman and little bluestem, *Schizachyrium scoparium* (Michx.) Nash (Gramineae). The junior author observed several hundred clusters of unidentified larvae feeding on the foliage of *Salix* spp. and *P. tremuloides*. Casual observation at this locality for at least the two years previous did not detect larval clusters. Several larval clusters were collected and returned to the laboratory for determination. Larvae were reared to maturity and identified by the senior author as *H. nevadensis*. The junior author also collected one larval cluster from bur oak, *Quercus macrocarpa* Michaux. This plant has not been previously reported as a food-plant for *H. nevadensis*. The closely related *H. maia* (Drury) has been reported to feed on various species of oak. However, *H. maia* is not known to occur in Manitoba. Tuskes et al. (1996) cited a record of *H. nevadensis* larvae feeding on coastal live oak, *Quercus agrifolia* Nee, in California.

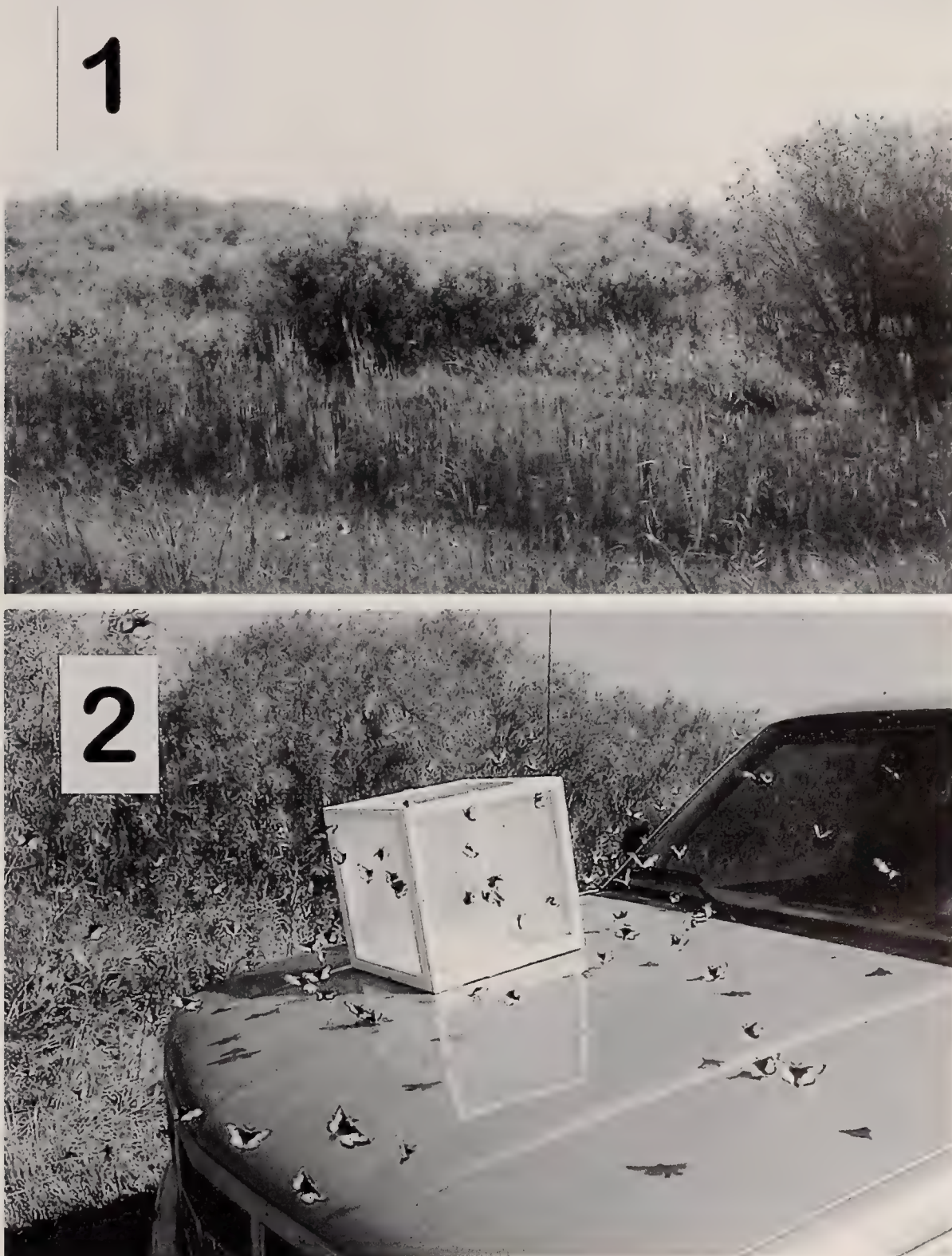
On 2 July 1998, the authors returned to the site of the original larval collections. At this time most larvae were in sixth-instar and could be collected by the hundreds from willow bushes in the area. Larvae were less commonly found feeding on foliage of *P. tremuloides* and *Q. macrocarpa*. Larvae that were feeding on *Q. macrocarpa* were stunted and appeared to be lagging a full instar behind larvae feeding on the other food-plants. One larva feeding on willow was observed under attack by a stink bug, *Apoecilus bracteatus* (Fitch) (Hemiptera: Pentatomidae). This predaceous stink bug is known to attack a diverse range of soft-bodied herbivorous insects (Evans & Root 1980). Kendall & Peigler (1981) reported that larvae of *Hemileuca grotei* Grote and Robinson were attacked by *Apoecilus cynicus* (Say) (cited as *Apateticus cynicus*) nymphs and adults.

Mature *H. nevadensis* larvae were noted to be polymorphic in coloration. The color of the integument ranged from yellow to almost completely black. Several hundred larvae were collected and returned to the laboratory in an effort to obtain parasitoids as well as living *Hemileuca* pupae. Pupae were maintained at 25°C and 14:10 photoperiod. Adults began emerging in the laboratory during late August 1998. Approximately one-half of the pupae did not produce adults and remained in diapause until the following fall. Tuskes et al. (1996) reported that a portion of *Hemileuca* populations may overwinter as pupae.

On 7 September 1998, the senior author returned to the collection locality with five virgin females. These females began calling during mid-morning, while enroute from Winnipeg. When the locality was being approached, males began following the vehicle. As soon as the vehicle stopped, hundreds of males were observed arriving from all directions in an effort to locate and mate with the caged females (Fig. 2). When the cage was opened, allowing wild males access, copulation occurred within ten seconds. Shortly thereafter, the remaining males dispersed.

The rate of parasitism of *H. nevadensis* larvae was estimated to be approximately 20%. Several hundred tachinid puparia were obtained. Puparia were stored in a 5°C chamber for approximately three months and afterwards maintained at 20°C and 16:8 photoperiod until emergence of adult flies. Adults were identified as *Leschenaultia fulvipes* (Bigot) (Diptera: Tachinidae).





FIGS. 1, 2. *Hemileuca nevadensis* at the Manitoba Tall Grass Prairie Preserve. 1, Collection locality habitat, 10 km East of Roseau River. 2, Wild *Hemileuca nevadensis* males attracted to caged virgin females. Both photos taken 5 September 1998 by DCH.

This species has not been recorded as attacking *H. nevadensis*, but has been recorded from *H. maia*, *H. grotei*, and *H. lucina* (Arnaud 1978, Kendall & Peigler 1981, Peigler 1994). Members of this genus lay mi-

crotypes eggs on foliage. Eggs hatch shortly after ingestion by the host (Brooks 1946). A figure of this parasitoid ovipositing at *Hemileuca* larvae is in Tuskes et al. (1996:26). Preserved egg rings, larvae and adults of *H.*



*nevadensis*, and adult *Leschenaultia fulvipes* were deposited in the J. B. Wallis Museum of Entomology, University of Manitoba Department of Entomology.

Identification of adult *Hemileuca* followed the descriptions of Ferguson (1971) and Tuskes et al. (1996). It should be noted here that Ferguson (1971) referred to the Manitoba populations of *H. nevadensis* as *latifascia* Barnes and McDunnough. The population of *Hemileuca* near Roseau River, Manitoba seems to be somewhat enigmatic. The association of several larval clusters with *Q. macrocarpa* would appear to be a *H. maia* trait. Ferguson (1971) was unsure that *H. nevadensis* warranted treatment as a 'full' species, since he could not distinguish the genitalia from those of *H. maia*. Ferguson (1971) also discussed the existence of transitional populations between *maia* and *nevadensis* in the Midwest. The *H. nevadensis* population near Roseau River, Manitoba may represent one such transitional population. Tuskes et al. (1996) discuss the taxonomic problems associated with this genus in the Great Lakes region and assert that more research on *Hemileuca* populations in this region is needed to resolve their taxonomic status.

The authors wish to thank J. E. O'Hara of Agriculture and Agri-Food Canada for identification of tachinid adults. Thanks are also extended to Dr. Abner Hammond, Louisiana State University, for helpful comments and criticisms of this manuscript.

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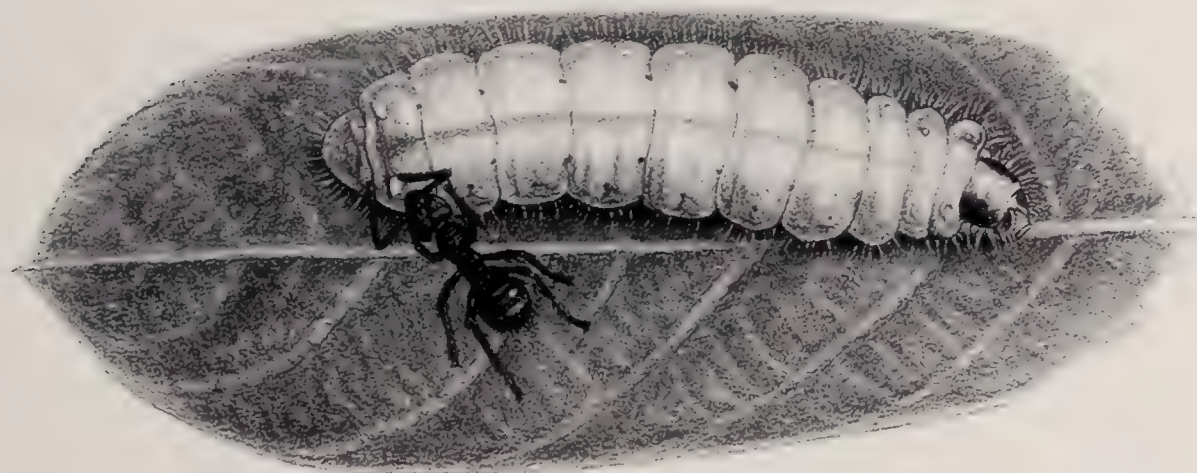
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## CATERPILLAR CALLS



The illustration depicts a *Eurybia patrona* (Riodinidae, Eurybiini) caterpillar delivering food secretions to an ant from paired tentacle nectary organs located on the caterpillar's eight abdominal segment. Drawing by J. Clark In: DeVries, P.J. 1997. Butterflies of Costa Rica and their natural history: Riodinidae. Princeton University Press.

In addition to amino acid-rich secretions that reward symbionts in exchange for protection, myrmecophilous lycaenids and riodinids produce substrate-borne calls that attract and maintain ant guards. Call mechanisms vary within the Riodinidae, and between riodinids and lycaenids, as does the location and structure of the secretion-producing organs. Nonetheless, call production has been demonstrated as being of critical importance to the maintenance of a guard of ants. Although most caterpillars eat plant tissue (leaves or flowers), some myrmecophilous riodinids are free-living carnivores, and some lycaenids spend part of their life inside ant nests feeding on ant regurgitations and ant brood.



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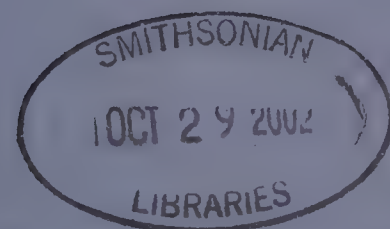
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# JOURNAL OF THE LEPIDOPTERISTS' SOCIETY

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## IMMATURES, NATURAL HISTORY AND THE SYSTEMATIC POSITION OF *BIA ACTORION* (NYMPHALIDAE)

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**ABSTRACT.** The early stages of the Amazonian nymphalid butterfly *Bia actorion* were studied in four localities (three in Brazil and one in Ecuador). The eggs bore multiple transverse and longitudinal ridges. First instar larvae had a setose head-capsule without scoli. All other instars were characterized by basally fused, highly ramified and setose head scoli, and a bifurcate plate on the tenth abdominal segment. These characters indicate that this species (and its monotypic tribe) belong within the Brassolinae.

**Additional key words:** Areaceae, Brassolinae, life history, Satyrinae.

The genus *Bia* Hübner is monotypic, and its only species, *Bia actorion* (Linnaeus, 1763), is found throughout the Amazon from low to mid elevations in the understory of dense forests (Masters 1970). Immatures of this species were unknown, and the only studies on *Bia* were based on morphological characters of the adults (Miller 1968, Vane-Wright 1972).

There is disagreement among authors regarding the systematic position of the genus *Bia*. Weymer (1912) placed it in the Satyridae, and his classification was maintained by Ehrlich (1958), Miller (1968) and Harvey (1991); while Clark (1947, 1948) classified *Bia* in the Brassolidae, an opinion that was not widely followed. The currently accepted position of *Bia* follows Miller (1968) who included it in its own tribe Biini (subfamily Biinae, Satyridae), along with two other

tribes, Antirrhini and Melanitini. Based on a cladistic analysis of early stage characters, DeVries et al. (1985) revised Miller's (1968) classification of Biinae by transferring Antirrhini to the Morphinae. Although *Bia* was not included in their analysis, DeVries et al. (1985) noted that it possesses exposed dorsal androconial patches similar to those of *Caligo* (Brassolinae), and suggested that early stages would be informative for determining the systematic position of *Bia*.

This paper describes the immature stages of *Bia actorion* and discusses the systematic position of this species within the Nymphalidae.

### STUDY SITES

Adults and immatures of *Bia actorion* were observed and collected in the field in four different localities in the Neotropics: the DBFF project reserves north of Manaus, Amazonas, Brazil (1981); Reserva Extrativista do Alto Juruá, Upper Juruá River,

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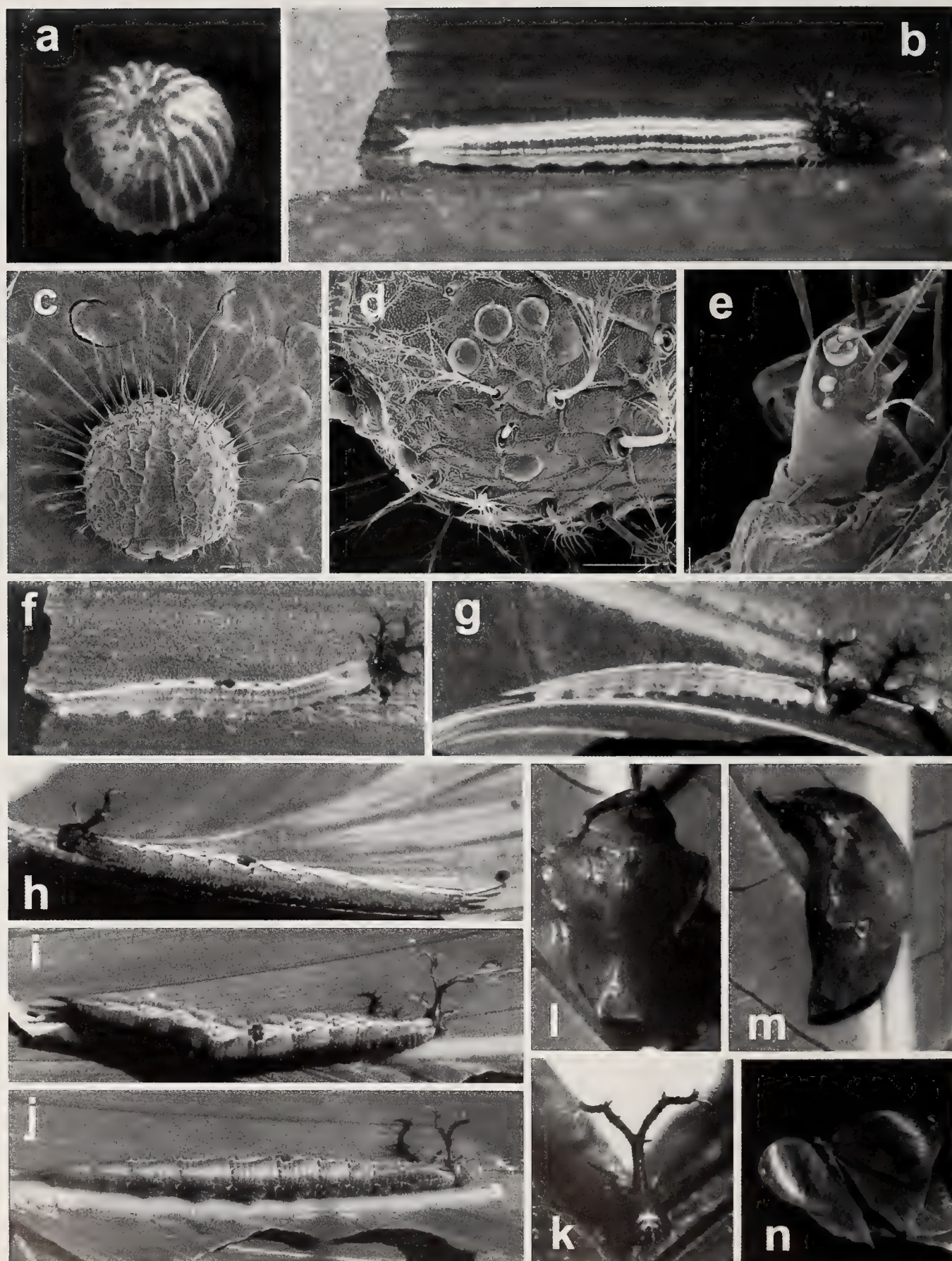


FIG. 1. Early stages and adult natural history of *Bia actorion*. **a**, egg; **b**, first instar; **c**, head capsule of first instar; **d**, lateral view of head capsule of first instar showing stemmata; **e**, antenna of first instar; **f**, second instar in molt; **g** third instar; **h**, fourth instar; **i**, **j**, fifth instar; **k**, frontal view of fifth instar head; **l**, **m**, pupa (ventral, lateral); **n**, perched adult flashing wings (dark brown, with blue and yellow on forewing).



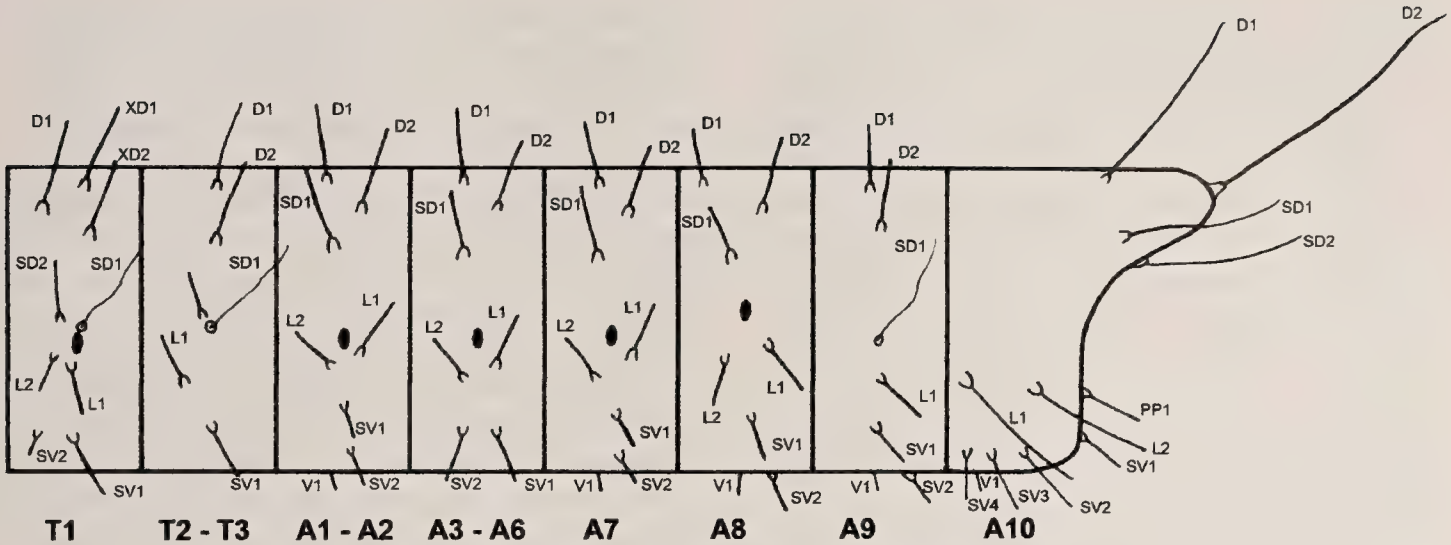


FIG. 2. Chaetotaxy of the first instar larva of *Bia actorion*.

Marechal Thaumaturgo, Acre, Brazil (1989–1998); Jatun Sacha Biological Station, upper Napo River, eastern Ecuador (1993), and Cristalino Jungle Lodge, Rio Cristalino, Alta Floresta, northern Mato Grosso, Brazil (2000).

MATERIALS AND METHODS

Immatures were collected in the field in Ecuador, while in Brazil eggs were obtained from a female confined in a plastic bag with leaves of the host plant (Alta Floresta, following Freitas 1991) or through expression of the abdomen of gravid females (see Brown & Benson 1974). Immatures were reared in plastic containers, cleaned daily, and fresh plant material was provided every 2–3 days. Data were taken on behavior and development times for all stages, and head capsules and pupal castings were preserved. Immatures were fixed in Kahle (AVLF collection) or preserved in 70% ethanol after being immersed in boiling water for several seconds (DM collection). The cephalic capsule was sputter coated with gold and observed in scanning electron microscopy (Jeol JSM-5800LV). Nomenclature of body setae follows Nakanishi (1988).

RESULTS

**Host plants.** The host plants of *Bia actorion* were palms (Arecaceae) in all study sites. In Ecuador the host plant was the spiny palm *Astrocaryum murumuru* Martius, 1824. In Alta Floresta females were observed flying around a species of *Geonoma* palm without spines, which was used successfully as host plant. In Manaus and the Upper Juruá the palm species were not identified, but were similar to, and possibly also members of the genus *Geonoma*, used for rearing the

larva in the former case (transplanted in Monjolinho arboretum, Campinas, São Paulo, Brazil).

**Oviposition and larval behavior.** At midday on May 2, 1993, at Jatun Sacha, Ecuador, a female was observed ovipositing on a *A. murumuru* palm. Eggs were laid singly on the spines emerging from new palm fronds, or on detritus caught on the palm fronds. Oviposition was a lengthy process, with the female resting for several minutes between each egg-laying episode. Once an oviposition site was selected, the female rubbed her abdomen back and forth several times before laying eggs. The observed female laid six eggs on a single palm tree before moving off rapidly into the forest.

In Ecuador, the host plant was a tall palm tree (about 15 meters high) while in Manaus the probable host was a very small plant. In Alta Floresta and Acre, females were also observed flying around small understory palms.

Once hatched, larvae were active and moved around on the hostplant, unlike the sluggish behavior of typical satyrids (pers. obs.).

**Diagnosis for mature larva.** Head dark brown with a pale brown stripe outlining frons and a pale brown lateral stripe; dorsal head scoli fused at base, ramified and with many setae; apical and subapical setae inserted into elongated tubercles. Body slender, green, with a bright white dorsal stripe; long bifid tail present on the last abdominal segment.

**Description of early stages.** All life stages are described below based on specimens from Brazil and Ecuador.

**Egg** (Fig. 1a). Gray-white when first laid, becoming purple and pinkish-gray as the developing larva takes



form; spherical with 25–30 longitudinal ribs and up to 50 less well developed transverse ribs; height 1.2 mm, diameter 1.4 mm ( $n = 10$ , Alta Floresta). Time of development: Ecuador—9 days ( $n = 6$ ); Alta Floresta—8–10 days ( $n = 30$ ).

**First instar** (Fig. 1b–e). Head brown; setae numerous, long, black, and plumose; setae projecting anteriorly; two pairs of chalazae on vertex of head capsule. Head capsule width 0.96 mm; setae length 0.1–0.5 mm. (material from Alta Floresta, Fig. 1c). Body green, smooth, with one dorsal and three lateral red stripes, wider dorsally; T1 with a heavily sclerotized, smooth, prothoracic shield; more lightly sclerotized patch with cuticular spinules surrounding XD2 and extending dorsolaterally to posterior edge of segment; XD and D setae on T1 with bulbous apex; excepting SV and V, all abdominal setae dark, heavily sclerotized at base and with sharp spines along shaft; SD1 filiform and long on thorax and A9; L2 filiform but not long on thorax; caudal filaments well developed; D2 setae on A10 long. Body chaetotaxy illustrated in Fig. 2. Maximum length 9 mm (Alta Floresta). Duration of instar: Ecuador—11 days for 4 larvae; Alta Floresta—8 days for 30 larvae.

**Second instar** (Fig. 1f). Head dark brown dorsally and light brown ventrally and basally; two dark brown scoli at vertex of head capsule, fused into one trunk for dorsally projecting basal portion, then separating into two projecting dorsolaterally, with apex curving posterolaterally; setae on scoli plumose; two smaller pairs of dark brown subdorsal scoli on head capsule; anterior scolus projecting anteriorly and posterior scolus projecting posterolaterally, both scoli curved before apex; setae on head capsule fine and short, except setae surrounding stemmata and on base of head capsule, that are dark, thick, and plumose; microgranulations on surface of scoli and (more finely) on surface of head capsule; head capsule with weakly developed ridges in the integument. Head capsule width 1.1 mm (only 15% wider than first instar, but twice as high due to scoli); anterior scolus 0.6 mm; posterior scolus 0.8 mm; scolus on vertex: fused trunk 0.6 mm, free arms 1.1 mm (material from Alta Floresta). Body slender, dark green; dorsal median stripe bright white; red spot on A3 along midline; laterally reddish green from A8 to posterior end; caudal projections long, dark green, and projecting laterally; numerous small secondary setae on body; SD1 filiform on T1–T3, A3–A7, and A9; L2 also filiform on T1; all filiform setae with small, slightly elevated bases and light sclerotized patch. Maximum length 15 mm (Alta Floresta). Duration of instar: Ecuador—9 days ( $n = 3$ ); Alta Floresta—14 days ( $n = 25$ ).

**Third instar** (Fig. 1g). Head as in previous instar except for the following: head capsule all dark brown including basally, with pale brown stripe outlining frons and pale brown lateral stripe; setal bases surrounding stemmata and on base of head capsule larger, with setae emerging subapically; large, elongate setal bases present on apex of each scolus and several along shafts, all emerging subapically with apex smooth and pointed; integumental ridges outlining faint, shallow depressions on head capsule. Head capsule width 1.5 mm; anterior scolus 0.8 mm; posterior scolus 1.2 mm; scolus on vertex: fused trunk 1.0 mm, free arms 1.8 mm (material from Alta Floresta). Body same as in previous instar except lateral red coloration present on abdominal segments. Maximum length 30 mm (Alta Floresta). Duration of instar: Ecuador—10–11 days ( $n = 2$ ); Alta Floresta—11 days ( $n = 20$ ).

**Fourth instar** (Fig. 1h). Very similar to third instar, with the general patterns darker than in previous instars. Head capsule width 2.1 mm; anterior scolus 1.3 mm; posterior scolus 1.8 mm; scolus on vertex: fused trunk 1.8 mm, free arms 2.7 mm (material from Alta Floresta). Maximum length 35 mm (Alta Floresta). Duration of instar: Ecuador—9 days ( $n = 2$ ); Alta Floresta—11 days ( $n = 16$ ).

**Fifth instar** (Fig. 1i–k). Head same as previous instars except for the following: head capsule and scoli black frontally and brown basally, with a white stripe laterally on head capsule; scoli larger than previous instar; more secondary setal bases on scoli and around stemmata and base of head capsule forming elongate projections with subapical setae; setal bases of these setae also larger than in previous instar. Head capsule width 2.9 mm; anterior scolus 2.2 mm; posterior scolus 2.5 mm; scolus on vertex: fused trunk 2.5 mm, free arms 3.1 mm (Alta Floresta). Body slender, green; dorsal median stripe bright white; stripe narrows abruptly at anterior edge of each segment and then widens to posterior edge, with size change greatest on A1 to A6; within white stripe thin gray line along midline and reddish gray coloration, darkest on A3, lateral to gray line at widest portion of white stripe; small white dots dorsolaterally and reddish-brown coloration ventrolaterally; caudal filaments long, dark greenish-gray, projecting laterally; secondary setae on body dark brown, wide, and flattened; filiform setae on body with heavily sclerotized and small setal bases, projecting only minimally from body surface and surrounded by large, sclerotized patch. Maximum length 55 mm (Alta Floresta). Duration of instar: Ecuador—10 days ( $n = 2$ ); Alta Floresta—14 days ( $n = 13$ ).

The larvae from Ecuador passed through an additional sixth instar. The head capsule was the same as in



the previous (fifth) instar; the body was the same except for more extensive reddish-gray coloration within the white stripe, reducing white coloration to a thin outline, and white dots dorsolaterally larger. Duration of instar: 22–25 days ( $n = 2$ ).

**Pupa** (Fig. 1 l–m). Short and bumpy, slightly curved anteriorly and strongly curved at A4. Entirely green, with dark lateral keels and a shiny dot near the wing caps. Total length 15 mm (Alta Floresta). Duration of pupa: Alta Floresta—17 days ( $n = 8$ ).

**Adult behavior.** Adults were found in dense forest with abundant small palms, including gallery (riparian) forests in an upland cerrado (savannah) landscape (Vilhena, 600 m, SE Rondônia, near Mato Grosso border, Brazil).

Adults fly in the understory and are active from before dawn to nightfall, being easily found in patches with rotting fruits on which they feed. During afternoons and on cloudy days, [the] males can be found in small openings in the vegetation, often near streams, but not always near areas with palms. Through marking of individuals (DM) males were found to persist for up to 20 days. Although some individuals moved from patch to patch over time, most remained loyal to a particular area. Interactions between males were common. No mating attempts with passing females were observed, although courtship behaviors were commonly seen. Courtship appeared to be lengthy and complex, including several different tandem flight patterns, male contact with females during flight, and solo male flight over perched females while they flash their wings. Occasionally courtship behaviors were observed between two males.

#### DISCUSSION

Regarding the controversy about the classification of *Bia* (Vane-Wright 1972, DeVries et al. 1985), the early stages give additional clues about its possible systematic position. The eggs, with many transverse and longitudinal ridges, and the first instar larvae with the head capsule lacking any kind of scoli and bearing long setae, giving a furry appearance, are most similar to those of the Brassolinae (Casagrande 1979, 1992, DeVries 1987). Although some Satyrinae have eggs with ridges (Emmel & Mattoon 1972), eggs of Brassolinae are distinctive in having many well-marked ridges (30–60), considered a trait exclusive to this subfamily (Freitas 1999). The mature larva also bears a typical brassoline feature, three pairs of scoli on the head capsule. This condition is observed in most Brassolinae (except in the gregarious *Brassolis*, that lack the head projections) and is absent in all known satyrine larvae, that show head capsules bearing a single pair of scoli

on the vertex (pers. obs). Additionally, palms are common host plants of Brassolinae, whereas in Satyrinae palm feeding is rare (DeVries 1987, Ackery 1988).

Based on adult morphology, *Bia* was suggested to be more closely related to Brassolinae than to Satyrinae (Vane-Wright 1972, DeVries et al. 1985). Our examination of early stages strongly supports this hypothesis. Confirmation must await a thorough phylogenetic study and broader sampling of immatures among Satyrinae and Brassolinae.

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## BIOLOGY OF *ANTHERAEA ANDAMANA* (SATURNIIDAE) ON THE ANDAMAN ISLANDS, INDIAN OCEAN

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**ABSTRACT.** *Antheraea andamana* was collected from the forests of South Andaman and Little Andaman, two islands in the Bay of Bengal, Indian Ocean. This is the first time that a saturniid is being reported from an island other than S. Andaman in this archipelago. The immature stages are described and illustrated for the first time.

**Additional key words:** Andamans, immatures, *Ficus*.

*Antheraea* Hübner (1819) is the largest saturniid genus in the Oriental Region, with species occurring from northeastern India to the western Moluccas and the eastern portion of Palaearctic Asia (Nässig et al. 1996a). In the Andaman islands this genus is represented by just one endemic species, *Antheraea andamana* Moore (Moore 1877, Watson 1911, Peigler 1989) (Fig. 1). Along with *Actias ignescens* Moore (another endemic species) and *Actias selene* (Hübner 1806) (now *A. callandra* Jordan, 1911; see Prashanth Mohanraj et al. 1996), it was among the first saturniids to be reported by Moore (1877) from the Andaman and Nicobar islands.

Here we report on the first captures of the immature stages of *A. andamana* from South and Little Andamans, and provide information on the natural history of this poorly known insular taxon.

### METHODS

Both adults and immatures were collected from South Andaman and Little Andaman. The two islands are separated by the 46 km wide Duncan Passage in the Bay of Bengal, Indian Ocean.

On South Andaman all stages of the moth were collected from *Ficus* trees, at three sites: (1) in the evergreen forest at Mount Harriet, (2) along the roadside at Homfraygunj where the original forest has been cleared and is now being cultivated, and (3) in the back mangals at Chiriyatapu. Mt. Harriet rises from sea level to a height of 365 m. A large *Ficus arnottiana* Miq. grows at the summit, from which larvae of *A. andamana* were collected. Eggs, larvae and pupae were also collected from *Ficus altissima* Blume at lower elevations along the Mt. Harriet range. A few *F. altissima* trees growing on roadsides in Homfraygunj yielded eggs, larvae and cocoons of *A. andamana*. Larvae and cocoons were taken from a group of *F. pretusa* L. trees in a stand of mangroves which had their bases periodically submerged by the rising tide.

At Little Andaman moths, eggs, larvae and cocoons were collected from the foliage of a stand of *Ficus pretusa* growing in a swampy area (Fig. 2) close to the sea.

All the material was collected from their host plants in forests and clearings. Several collecting methods were used. First, groups of 4 to 6 people inspected the foliage of trees manually with a pair of binoculars. Second, the ground beneath the canopy was searched for fecal pellets. Since the larvae apparently do not move large distances during their larval period the presence of feces, if fairly fresh, is a clear indication of their presence. Third, a long nylon rope with a stone tied to one end was thrown over high branches, and these were pulled down and scanned leaf by leaf. Lastly, trees were climbed and their foliage searched manually.

The largest number of *A. andamana* individuals was obtained by the fecal pellet method. This was also the most efficient in terms of number of individuals obtained per unit of search time. The primary disadvantage of this method was that only larvae were located. It also yielded a greater number of older than younger instars, as the larger fecal pellets of the later instars are more easily spotted.

All material collected was brought to the laboratory in individual plastic containers of various sizes (in keeping with the size of the stage caught). Eggs and larvae were then transferred onto bouquets of their food plants in flasks of water whose openings were tightly secured with cotton plugs. Each larva was then placed in a separate cage. Observations were made daily in the morning when the cages were cleaned and larvae provided with fresh food.

### NATURAL HISTORY

From our rearing experiences, the following descriptions of the immature stages of *A. andamana* can be offered (Table 1 and Fig. 3):

**Egg.** Dorsoventrally flattened with an irregular brown patch on top. Chorion mottled, mostly brown with small irregular dirty white patches. Chorionic surface honey-combed with shallow depressions. No

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FIG. 1. Adult females of *Antheraea andamana* Moore.

brown bands encircling the eggs. Inner surface pale brown, smooth and highly reflective. The eggs were laid singly or in batches of 2 or 3 on the ventral surfaces of leaves. Some were laid about 1 cm apart while others were laid in contact with each other.



FIG. 2. Brackish water swamp habitat of *A. andamana* at Little Andaman. A freshly emerged female moth was collected from the over hanging branches of *Ficus retusa* on the left of the picture.

**First instar.** Head deep brown to black, glossy with sparse white setae; clypeus, labrum and labium white; antennae/palp semitransparent golden brown or honey colored arising from a whitish base. Prothoracic shield glossy and of the same color as the head. Thoracic and abdominal segments creamish-yellow dorsally, tending towards white or pale yellow ventrally. A narrow brown band or line is present towards the anterior and posterior margins of each segment. The scoli are located between these bands. These bands take on a deeper hue a little above the lateral

TABLE 1. Developmental time and dimensions of the immature stages of *Antheraea andamana* on the Andaman islands.

Time of development (days)	Egg	Larval instars					Pupa	Total
		1	2	3	4	5		
All individuals	8.7 ± 0.8 n = 12	3.9 ± 0.6 n = 17	3.5 ± 0.5 n = 17	4.2 ± 0.8 n = 20	5.9 ± 1.4 n = 20	9.1 ± 0.9 n = 17	25.1 ± 3.0 n = 13	60.7
Males only	—	3.8 ± 0.5 n = 5	3.6 ± 0.6 n = 5	3.6 ± 0.9 n = 5	5.2 ± 0.5 n = 5	8.4 ± 0.9 n = 5	25.0 ± 1.4 n = 4	49.5*
Females only	—	3.8 ± 0.5 n = 5	3.6 ± 0.6 n = 5	4.6 ± 0.6 n = 5	5.2 ± 0.5 n = 5	9.0 n = 5	27.4 ± 2.7 n = 5	53.6*
Dimensions (cm)								
All individuals	3.7 ± 0.2 <sup>†</sup> x 3.3 ± 0.2 n = 30	0.7 ± 0.1 n = 30	1.6 ± 0.1 n = 18	2.8 ± 0.2 n = 20	3.8 ± 0.2 n = 20	5.2 ± 0.4 n = 19	5.3 ± 0.3** x 2.3 ± 0.3 n = 3	—
Males only	—	0.7 ± 0.1 n = 5	1.5 ± 0.1 n = 5	2.9 ± 0.2 n = 5	3.7 ± 0.2 n = 5	5.0 ± 0.2 n = 5	—	—
Females only	—	0.7 n = 4	1.7 ± 0.1 n = 4	2.8 ± 0.3 n = 4	3.7 ± 0.2 n = 4	5.4 ± 0.3 n = 4	—	—
Head capsule width (mm)		1.8 ± 0.1 n = 17	2.9 ± 0.1 n = 20	4.1 ± 0.1 n = 21	5.9 ± 0.2 n = 21	—	—	—

<sup>†</sup> Measurements in mm.  
\* Exclusive of incubation period.  
\*\* Dimensions of cocoon, not of pupa.





FIG. 3. Immature stages of *Antheraea andamana* Moore. **a**, Eggs. **b**, First instar larva. **c**, Second instar larva. **d**, Fifth instar larva. **e**, Fifth instar larva—close up of head. **f**, Fifth instar larva—anal proleg. **g**, Cocoon. **h**, pupa in ventral view.



scoli on the first to seventh abdominal segments while they retain the same intensity of brown throughout their length on the remaining segments. All scoli, with the exception of the dorsal scoli on the prothorax, basally yellow (of the same color as the rest of the body); terminally bulbous and transparent yellow from which arise five transparent, whitish setae tapering, towards their terminal ends and arranged in a rough circle from the center of which arises another seta. The dorsal scoli on the prothorax are very short and appear to have two conjoined heads with eight long whitish setae. Single, dorsal scolus on the eighth abdominal segment. Anal plate and outer lateral surface of anal prolegs deep brown. Spiracles on prothorax internally of the same color as the rest of the body with a narrow brown rim. Abdominal spiracles also brown rimmed, but with brown striations arising from the rim and running towards the center. Legs black with sparse, short, white setae and brown claws. Prolegs black distally with nine transparent white setae in the black region and brown crochets.

**Second instar.** Head deep brownish-black, with thin black sparsely distributed setae. Frons and outer margins of frontal and epicranial sutures pale brown; antennae brown, set in a white base; maxillary palp and labium partly white and partly black; labrum golden brown; clypeus white. Thoracic and abdominal segments yellow-green with small white, club-shaped setae. Prothoracic shield brown in the center of the anterior margin, becoming progressively paler laterally and posteriorly. Dorsal scoli on prothorax short, situated more towards anterior margin and with about 7 to 8 setae. The largest scoli are the dorsal scoli on the meso- and meta-thoracic segments. They are also the only tri-colored scoli being black terminally, followed by an orange-brown band and yellow basally. All other dorsal scoli are small with an orange brown ring/band. On the eighth abdominal segment the dorsal scoli are fused but distinctly bifurcated on top with 8 brownish setae (6 forming a rough circle with 2 in the center). Subdorsal and subspiracular scoli are small, orange-brown with terminal crown of black or brown setae. Prothoracic spiracle yellowish; all other spiracles deep brown to black except for that on the eighth abdominal segment which is brownish-white. Subspiracular line faint yellow anteriorly and more prominent posteriorly particularly on segments 7 and 8 where it gradually turns brown. It is narrow anteriorly, becoming broader towards the rear. The anal plate is black and fringed with brown setae along the outer margins. The lateral surface of the anal prolegs have a deep brown to

black triangle with a basal yellow patch. Ventral surface is yellowish-green with short white and longer brown fine setae on first and second abdominal segments. Legs are black with brown claws while the prolegs are yellowish brown distally with black setae arising from the center of small, black, circular spots. Crochets are brown.

**Third instar.** Head brown to black in color with white clypeus and white and brown labrum. Bases of antennae a rich cream to yellow. The rest of the larva is greenish yellow. Prothoracic shield yellow, tinged with brown anteriorly. Scoli very small and brown with one long and 5 to 6 short, spiny, brown setae. Dorsal scoli on meso and meta thorax terminally deep brown to black with an annular brown ring beneath them and the basal two-thirds distinctly yellow (more intense than the rest of the body). The subspiracular scoli in this instar are blue on all the segments, the blueness being most pronounced on the first three abdominal segments. Spiracles on the first seven abdominal segments are black while that on the eighth abdominal segment is pale brown with a silvery-white longitudinal line in the center. The lateral yellow line is prominent. It is darker and broader towards the anal end becoming progressively narrower and less distinct as it approaches the first abdominal segment where it terminates. Though greenish-yellow overall, the "green-ness" is more pronounced below the lateral line than above it. Ventrally, all the thoracic segments and the posterior abdominal segments from seven to the anal tip are yellow. The remainder of the ventral surface is green with a mid-ventral yellow line. Legs deep brown to black with brown claws. Prolegs distally brown and yellow proximally. In the yellow area are circular brown spots of variable size and each has a brown seta in the center—most are long, a few are short. Laterally, the anal prolegs have a brown triangle.

**Fourth instar.** Head and mandibles deep burnt brown; frons and labrum cream, clouded with brown. The rest of the body (including the ventral surface) is pale green—of the same shade as the under surface of the leaf on which it feeds. (The dorsal surface of the leaf is a deeper green). Short brown setae are sparsely distributed over the entire body surface. Prothoracic shield is cream anteriorly and brown posteriorly. The yellow supraspiracular line is broad posteriorly and narrows progressively towards the anterior end to terminate abruptly above the first abdominal spiracle. It does not extend onto the thoracic segments. Dorsal scoli on thorax not prominent but visible as pale yellow circular patches with brown centers. Spiracles deep brown and ringed with a narrow pale yellow band.



**Fifth instar.** Head burnt brown in color with labrum, clypeus, frons and broad regions on either side of the epicranial suture pale dirty brown. The rest of the larva is pale green, becoming a shade darker below the spiracles. Prothoracic shield also burnt brown. Supraspiracular line yellow and enclosing the top one-third of the eighth abdominal spiracle. This line passes above the seventh abdominal spiracle and keeps going progressively higher up to the first abdominal segment where it abruptly stops. The row of black setae on the lateral scoli below the spiracle on each abdominal segment arises from a small, pale blue patch on segments one to six, with the last two patches being very small and very faintly blue.

**Cocoon.** Stalked and spun between leaves such that it is almost totally covered with leaves. It is brown in color, greying as it ages; and the opening from which the adult emerges faces the petiole.

**Biology.** Eggs, larvae and cocoons were found on *Ficus altissima* Blume, *Ficus arnottiana* and *Ficus ?retusa* (Moraceae). The larvae completed their life cycles when reared on the foliage of all these species of trees in the laboratory. We observed various stages of the moth on their host plants in the months of January, February, March, September, October, November and December. Two species of hymenopterous parasitoids emerged from eggs collected at various times from the field: both species exhibited superparasitism with all individuals of one species emerging from a single exit hole while all individuals of the second species emerged by making multiple exit holes in the chorion of the eggs. Some larvae succumbed to attack by the nuclear polyhedrosis virus while being reared in the laboratory.

#### DISCUSSION

Moore (1877) described *A. andamana* from specimens in the Natural History Museum, London. He neither illustrated nor furnished characters to distinguish it from other members of the genus. Cotes (1891–1893) was unable to verify its status as he could not access the specimens in London and there were no specimens in the Indian Museum (now the Zoological Survey of India, Calcutta). This led him to list this species along with four others as requiring confirmation of their specific status. It is also significant that Arora and Gupta (1979) do not even list it among the seven species of *Antheraea* that they deal with in their study of Indian non-mulberry silk moths. Apparently the Z.S.I. had failed to procure specimens from the Andaman islands in the 100 years since its first description.

It is pertinent to state here that since sericulture was not practised on the Andaman islands genetic contam-

ination of the native saturniids is unlikely to have occurred by release of cultivated stock.

*Antheraea andamana* belongs to the *frithi* subgroup of the *paphia/frithi* group of the subgenus *Antheraea* (Nässig et al. 1996b). So far the immatures of only a few species in this subgroup are known and, of these, most are only partially known (Nässig et al. 1996b, Holloway et al. 1996 and references therein). Only the life history of *A. rumphii rumphii* C. Felder from Ambon, Indonesia has been fully worked out (Paukstadt et al. 1996).

The only preimaginal character that Nässig (1991) and Nässig et al. (1996a) currently use in defining the *paphia/frithi* group is the usual presence of “a double ring of brownish color around the top and bottom of the flattened egg”; also known as “equatorial lines” (Jolly 1980). These lines are obsolete in *A. andamana* though present in its sister taxon *A. rumphii* (Paukstadt et al. 1996). If this is found to be a useful character when the ova of more species in the *frithi* subgroup are described then perhaps the presence/absence of this character would serve to further subdivide this large and diverse subgroup. Nevertheless, until more information is generated on the biology and preimaginal morphology of species in the *paphia/frithi* group it will remain difficult to characterise the “limits of the different species” (Nässig et al. 1996a).

As reported by Paukstadt et al. (1996), we also did not find silvery patches encircling the dorsal and supraspiracular scoli in any of the instars. Though Nässig et al. (1996b) say that the presence of these patches or rings is only facultative, they qualify their statement, saying that their total absence varies individually. We found no traces of these patches in over 30 larvae bred in the laboratory. Nässig et al. (1996b) state that the dorsal scoli on A8 are at least basally fused, even if not totally fused, in the known mature caterpillars. In mature larvae of *A. andamana* these scoli on A8 maintain their distinct identities; it is only in the early instars that they are basally fused in *A. andamana*.

*Antheraea paphia* L. is the only species in the genus *Antheraea* so far known to utilize species of *Ficus* as larval food plants (Stone 1991). *Ficus* spp. have now been found by us to be fed on by *A. andamana*, a species in the *frithi* subgroup, but in the same group as *A. paphia*. *Antheraea moultoni* Watson and *Antheraea brunei* Allen and Holloway are the only species in this genus that have been collected in or close to mangroves (Holloway 1987). The life histories of these species remain unknown, though first instars of *A. brunei* were obtained from eggs by Naumann (1994); these did not take any of the food plants he offered; *Ficus* was not included among them. Nässig et al. (1996a) however infer that *A. brunei* is a mangrove specialist. One of the habi-



tats from which *A. andamana* has been collected by us is from brackish water *Ficus* swamps behind coastal mangroves in Little Andaman. It was also bred on this species of *Ficus*. These *Ficus* swamps are much drier in summer than during the monsoon, making them seasonal as opposed to permanent swamps. In South Andaman, on the other hand, we have found them breeding in the back mangals where the bases of the trees are submerged throughout the year during high tide.

Rumphius (1627–1702) was the first to describe and illustrate the larva and cocoon of a species of *Antheraea* (namely *A. rumphii* C. Felder) along with its larval food plant (*Sonneratia caseolaris* L.: Sonneratiaceae) (Diakonoff, 1959). Paukstadt et al. (1996), referring to the 'Herbarium Amboinense' misinterpreted the host plant 'Mangium Caseolare Rubrum' as *Rhizophora caseolaris* L. This error may also be found in Arora and Gupta (1979) and Stone (1991). 'Mangium' is a generic name that Rumphius applied to all mangrove plants (Tomlinson 1986). 'M.C. Rubrum' as mentioned and illustrated in 'Herbarium Amboinense' is *S. caseolaris* L. (de Wit 1959). *A. rumphii* also belongs to the *frithi* subgroup like *A. andamana*.

We note here that the Italian zoologist-cum-anthropologist Cipriani (1966) apparently had earlier made some observations on *A. andamana* (he called it *A. paphia*) when he was residing on Little Andaman studying the *Onge*, one of the four negrito tribes of these islands. He mentions *Ficus* as the larval food plant and describes how the larvae spin their stalked/petiolated cocoons. He says there are two broods, with the adults appearing in mid September and mid February. The adults, after emerging from their cocoons and spreading their wings, were observed by him to 'sleep for two days, to wake up on the second night' when the 'active males seek and mate with the near sedentary females.' He also noted that 'virgin females attracted males from many kilometers away as is the case with *Saturnia pyri*.' This is an observation that we have so far not been able to repeat with any of the saturniids from the Andaman islands.

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## A REVISION OF THE GENUS *BULIA* WALKER (LEPIDOPTERA: NOCTUIDAE)

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**ABSTRACT.** A phylogenetic revision of the genus *Bulia* Walker is provided and includes a key to species, descriptions, illustrations of adults, both male and female genitalia, and distribution maps. The relationships among the five species of *Bulia* are based on an analysis of 16 characters. The monophyly of *Bulia* is supported by 7 nonhomoplasious synapomorphies. *Arsisca bolinalis* Walker 1866 is proposed as a **new synonym** of *Bulia confirmans* (Walker) 1858 and *Bulia morelosa* Richards 1941 as a **new synonym** of *Bulia similaris* Richards 1936. Larval host plants are recorded for the first time for *Bulia confirmans*, on *Jatropha gossypifolia* (L.) (Euphorbiaceae), and for *Bulia mexicana* (Behr), on *Prosopis juliflora* (Sw.) DC. (Fabaceae).

**Additional key words:** Lepidoptera, Noctuidae, *Bulia*, cladistics, key to species, larval plant hosts, Euphorbiaceae, Fabaceae.

The genus *Bulia* Walker 1858 was first revised by Richards (1936a). In this revision, he described a new species, *B. similaris* Richards, designated a neotype for *B. mexicana* (Behr) 1870, and concluded that these two species can only be separated from *B. deducta* (Morrison) 1875 by structures of the male and female genitalia. The maculation of the adult is useless due to the tremendous amount of inter- and intraspecific variability and degrees of sexual dimorphism that these species exhibit. Richards (1936b) described and diagnosed *Bulia* in regards to the *Phoberia-Melipotis-Drasteria-Boryza* group of catocaline genera. A second revision by Richards (1941) incorporated additional material from Mexico and Central America and included two new species, *B. schausi* and *B. morelosa*, and a race of *B. similaris* from California (*californica*).

The need for this third revision came about during the curation of the Nearctic Catocalinae at the National Museum of Natural History (USNM) by the senior author. After obtaining specimens from other collections, there was substantially more material available for study, especially from Mexico, than what Richards had seen.

### MATERIALS AND METHODS

A total of 2319 specimens were examined. The institutions from which specimens were examined are presented in Table 1.

Material was identified by using the revisions of Richards (1936b, 1941) and by comparing his identified material with the unknown specimens. Richards' material included specimens of *B. deducta* that were compared with the types at The Natural History Museum, London (BMNH), and the types of *B. similaris*, *B. mexicana*, *B. schausi*, and *B. morelosa* at the USNM were examined.

After removing the abdomen from the specimen it was placed in a 10% solution of postassium hydroxide (KOH) and heated in a Thermolyne® Type 17600, Dri-Bath for approximately 20 minutes or until the abdomen was soft and the muscles dissolved. The abdomen was descaled and the internal organs removed. The specimen was then identified and the abdomen, with genitalia attached, was placed in a genitalia vial containing glycerin and pinned beneath the specimen.

For specimens that were slide mounted, the abdomen was stained in an aqueous solution of Chlorazol Black E. The male aedoeagus was removed from the genitalia and the vesica was inflated using a syringe filled with 99% isopropyl alcohol. The abdominal pelt and the rest of the genitalia were placed in solutions of 40% and 70% ethanol for an hour. The abdomen, genitalia, and aedoeagus were then stained in Eosin Y dissolved in 99% isopropyl alcohol until the desired color was achieved. The female genitalia were treated in a similar manner. The genitalia and abdomen were then mounted on a slide using Canada Balsam.

### PHYLOGENETICS

The taxa analyzed included 5 species of *Bulia* and two outgroup taxa, *Melipotis jucunda* (Hübner) 1818 (type species of *Melipotis* Hübner 1818) and *Drasteria fumosa* (Strecker) 1898. The outgroups were selected based on the results of Richards (1933, 1936b), who included these genera and *Litocala* Harvey 1875 and *Hypocala* Guenée 1852 as his "group 3" and stated that "This is probably the best defined of all the erebine groups." This group is based on shared characters of the thoracic tympanum (Richards 1933): (1) nodular sclerite shape, (2) pocket I pouched, and (3) pocket IV flanged.



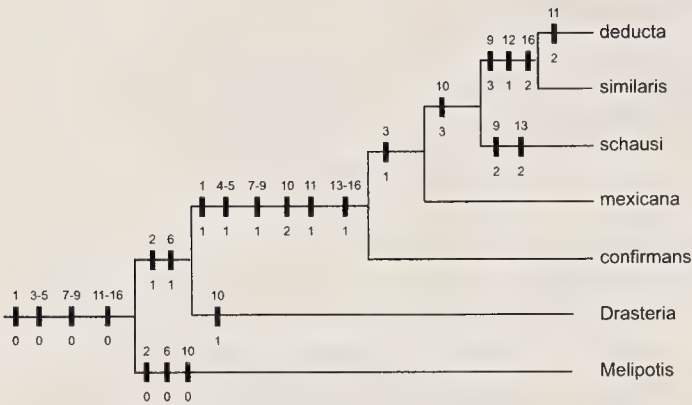


FIG. 1. Cladogram of the species of *Bulia*. Synapomorphies refer to solid black rectangles with character numbers on top and state numbers on bottom. Tree length 25, consistency index (C.I.) 1.00, retention index (R.I.) 1.00.

**Characters and states.** All characters were run as ordered with their inferred plesiomorphic and apomorphic states shown in Appendix 1. Plesiomorphic states were inferred by outgroup comparison. A total of 16 characters were used including 11 binary and 5 multistate characters (Appendix 1). Data were analyzed using the Hennig86 parsimony program written by Farris (1988, Version 1.5). The command “mhennig\*” was used for the data matrix in Appendix 2, and all characters were treated as ordered. The “mhennig\*” command constructs several trees, each by a single pass, adding the taxa in a different sequence each time, and then applies branch-swapping to each of the trees, retaining just one tree for each initial one (Lipscomb 1994).

**Results.** Applying “mhennig” to the data matrix (Appendix 2) resulted in a completely resolved tree with a length of 25, a consistency index (C.I.) of 1.00, and a retention index (R.I.) of 1.00.

The resulting cladogram is shown in Fig. 1 and illustrates the monophyly of *Bulia* based on the following characters: (1) head with an elongate projection from vertex (Fig. 3); (2) eighth tergum mostly membranous, with a narrow X-shaped tergite (Fig. 31); (3) eighth sternum mostly membranous, with a wine glass shaped sternite (Fig. 32); (4) clasper absent from valva (Figs. 34–38); (5) clavus absent from valva (Figs. 34–38); (6) coremata of male arising from base of eighth tergite (Fig. 33); and (7) ventral plate of ostium bursa in female attached to seventh sternum (Figs. 49–53).

*Bulia confirmans* (Walker) is the most plesiomorphic species for the analyzed characters and occurs in the Caribbean and northern South America; the remaining species of *Bulia* are distributed from the southwestern United States, throughout Mexico to Costa Rica. *Bulia confirmans* is the only species which can be identified without resorting to genitalia and the larvae feed on Euphorbiaceae, while the rest of the

TABLE 1. Acronyms of institutions from which specimens were examined.

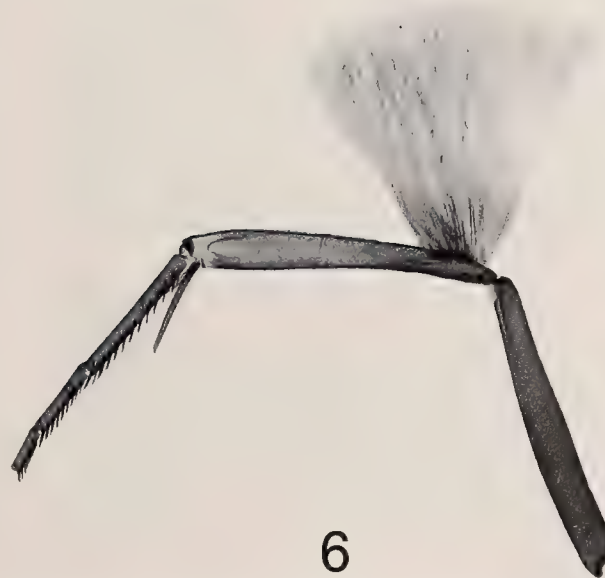
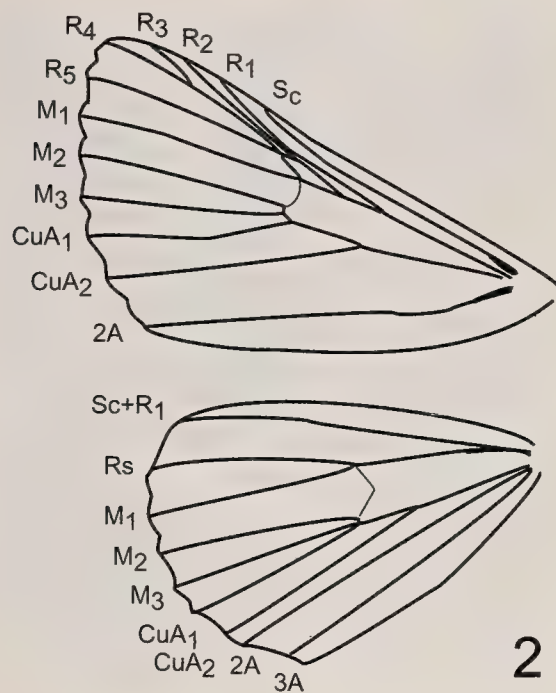
AMNH	American Museum of Natural History, New York, New York
BMNH	The Natural History Museum, London
BrM	Bryant Mather, Clinton, Mississippi
CNC	Canadian National Collection, Ottawa, Ontario
INBIO	Instituto Nacional de Biodiversidad, Costa Rica
SDNH	San Diego Natural History Museum, San Diego, California
UCB	Essig Museum of Entomology, University of California, Berkeley, California
UNAM	Instituto de Biología, Universidad Nacional Autónoma de México, México City
USNM	National Museum of Natural History, Washington, D.C.

*Bulia* species whose host plants are known feed on Fabaceae. *Bulia mexicana* shares the short apex of the sacculus with *B. confirmans* (character 11, state 2). The elongate apex of the sacculus unites *schausi*, *similaris*, and *deducta* (character 11, state 3). Autapomorphies for *B. schausi* include the large costal lobe of sacculus with a slightly bifurcate apex (character 10, state 2) and the vesica containing one large spine (character 14, state 2). The V-shaped dorsal margin of the juxta in the male genitalia is diagnostic for *B. deducta* (character 12, state 2).

LARVAL HOST PLANTS

Three species of *Bulia* have been reared. A single female specimen of *B. confirmans* was reared from a larva that bored into the stem of *Jatropha gossypifolia* (L.) (Euphorbiaceae) from Nueva Esparta, Isla de Margarita, Venezuela. *Jatropha gossypifolia* occurs throughout Mexico, the Caribbean, and South America from Venezuela south to Brazil, Bolivia, and Paraguay. This distribution completely overlaps the known localities of *B. confirmans*. Two other *Bulia* species with known host plants feed on *Prosopis* (Mesquite) (Fabaceae). *Bulia mexicana* was reared on *Prosopis juliflora* (Sw.) DC. from Area de Conservación Guanacaste, Sector Santa Rosa, Estero Naranjo, Guanacaste Province, Costa Rica. *Prosopis juliflora* is distributed from western and southern Mexico through Central America to Venezuela, Colombia, Ecuador, and northern Peru. This distribution overlaps that of the known distribution of *B. mexicana*. *Bulia deducta* (Morrison) was reared from an unknown species of *Prosopis* from the vicinity of Presidio, Presidio County, Texas. There are two species, *Prosopis glandulosa* Torr. and *Prosopis pubescens* Benth., that occur in the Presidio area (Simpson 1988). *Prosopis glandulosa* is the most widely distributed of these two species extending from southern Kansas, west to southern California and southern





FIGS. 2-6. 2, Wing venation of *B. confirmans*. 3, Descaled head of male *B. confirmans*, arrow indicates elongate median projection. 4, Broad scales enclosed in median projection. 5, Narrow scales enclosed in median projection. 6, Mesothoracic leg with hair pencil from apex of mesothoracic tibia.

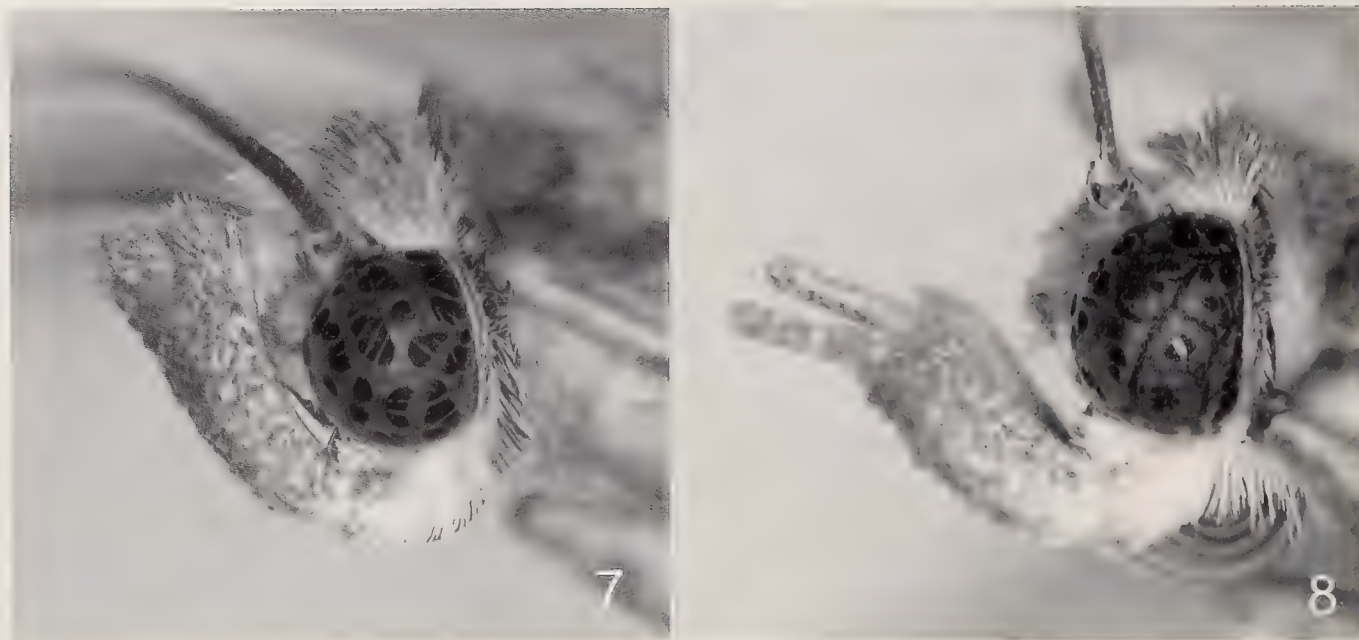
Utah, south through Texas, throughout northern Mexico, including Baja California, and down the east coast of Mexico through Veracruz and Yucatan. The range of *Prosopis pubescens* is from southwest Texas west to southern California and southwest Utah, south to northern Mexico including Baja California, Sonora, Chihuahua, and Coahuila. Based on the distributions of these species and that of *B. deducta* it is likely that *P. glandulosa* is the plant host of *B. deducta*. The other species of *Bulia* may also feed on *Prosopis*. The distri-

bution of *Bulia similis* Richards overlaps that of *P. glandulosa* and is sympatric with *B. deducta* in southern California and southern Texas. More rearing needs to be done in the southwestern United States to see if *Bulia* species are restricted to *Prosopis* or if they are on any related plant species.

#### *Bulia* Walker

*Biula* Walker [1858] 1857:1169 [type species: *Biula propira* Walker by monotypy.] Preoccupied by *Biula*





FIGS. 7–8. 7, Scaled head of male *B. deducta*. 8, Scaled head of female *B. deducta* showing differences in labial palps.

Walker [1858] 1857, Notodontidae. Nye, 1975:91; Poole 1989:163.

*Bulia* Walker 1858:1815 Proposed as an objective replacement name for *Biula* Walker [1858] 1857. Richards 1936a:431; Richards 1936b:365; McDunnough 1938:132; Richards 1941:255; Nye, 1975:91; Franclemont and Todd 1983:125; Poole 1989:180; Poole and Gentili 1996:729.

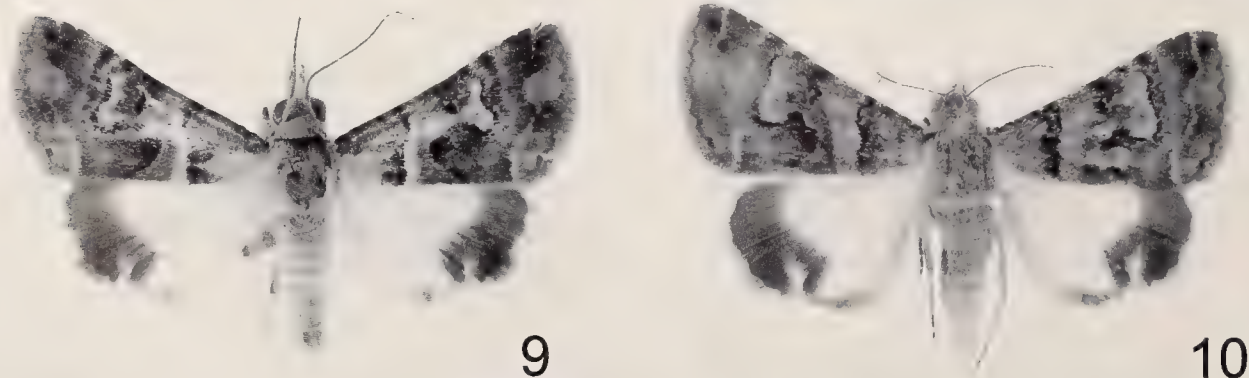
*Arsisaca* Walker [1866] 1865:1261 [type species: *Arsisaca bolinalis* Walker by monotypy.] Nye, 1975:62 [junior synonym of *Bulia*]. Poole 1989:126.

*Cirrhobolina* Grote 1875:117 [type species: *Syneda deducta* Morrison by subsequent designation by Kirby 1875:442.] Druce 1889:358; Smith 1891:58; Smith 1893:325; Dyar 1902 [1903]:222; Holland 1903:259; Barnes and McDunnough 1917:85; Richards 1936a:431 [junior synonym of *Bulia*]; Richards 1941:255; Nye 1975:123; Poole 1989:253.

*Cirrhobolina*; Dyar 1902 [1903]:222. An incorrect subsequent spelling.

**Diagnosis.** *Bulia* species can be confused with some species of *Drasteria*, *Melipotis*, and *Forsebia*. The best character to separate *Bulia* from these genera is the presence of an elongate median projection of the vertex (Fig. 3). The hindwing anal lunule is yellow in all North American species of *Bulia* and the anal lunule in the other genera, if present, is white. *Bulia confirmans* has a white anal lunule, but the brown border is narrower than in the other genera (Figs. 9–10). *Bulia confirmans* is also much smaller in forewing length (less than 15 mm) than the most similar species in the other genera (greater than 15 mm). *Bulia* is distinct from the other genera in the male genitalia. The valva lacks internal armature, such as the clasper, clavus, and ampulla, while these are all present in the outgroup genera and the coremata arises from the base of the eighth abdominal segment in *Bulia* (Fig. 33), but in the other genera the coremata (when present) arises from the base of the valva.

**Description. Head:** Vestiture rough, scales narrow, hairlike. Frons base bare, forming a triangle shaped area; frontal prominence



FIGS. 9–10. Adults of *B. confirmans*. 9, ♂, Venezuela, Trujillo, Valera (USNM). 10, ♀, Dominican Republic, Los Hidalgos (USNM).





FIGS. 11–14. Adults of *B. mexicana*. **11**, ♂, Mexico, Jalisco, Estación de Biología, Chamela (UNAM). **12**, ♀, Costa Rica, Guanacaste, Area de Conservación Guanacaste, Sector Santa Rosa, Estero Naranjo (D. H. Janzen & W. Hallwachs rearing voucher no. 97-SRNP-219). **13**, ♀, Costa Rica, Guanacaste, Area de Conservación Guanacaste, Sector Santa Rosa, Estero Naranjo (D. H. Janzen & W. Hallwachs rearing voucher no. 97-SRNP-85). **14**, ♀, Costa Rica, Guanacaste, Area de Conservación Guanacaste, Sector Santa Rosa, Estero Naranjo (D. H. Janzen & W. Hallwachs rearing voucher no. 97-SRNP-91).

present; scale tuft of frontal prominence directed dorsad; scales lateral to frontal prominence tuft directed dorsad and curved medially. Labial palpus appressed to front; middle segment elongate, more than 3 times length of basal segment; apical segment longer than basal segment, less than a third length of middle segment; apical segment wider in male than female and more concealed by scales of

both the median and apical segments, female apical segment narrow and prominent. Eye well developed. Ocelli present. Vertex with a pair of elongate (longer than head) triangular shaped projections (Fig. 3) that enclose 2 types of scales (Figs. 4–5) and a median elongate spine with a slightly decurved apex; projections invaginated into vertex. Vertex with lateral hairlike scale tufts from near antennal



FIGS. 15–18. Adults of *B. schausi*. **15**, ♂, Mexico, Distrito Federal (UNAM). **16**, ♂, Mexico, Veracruz, Orizaba (USNM). **17**, ♀, Mexico, Distrito Federal (UNAM). **18**, ♀, Mexico, Distrito Federal, Ajusco (UNAM).





FIGS. 19–24. Adults of *B. similaris*. **19**, ♂, California, San Diego Co., Oriflamme Canyon, Anza Borego State Park (USNM). **20**, ♂, Texas, Nueces Co., N. Padre Island (USNM). **21**, ♀, Mexico, Baja California Norte, 14.4 mi S Campo Alfonsina (SDNH). **22**, ♀, Mexico, Baja California Norte, 2.8 mi S of Catanina (SDNH). **23**, ♀, Mexico, Baja California Norte, 1.2–5.4 mi S Santa Ines (SDNH). **24**, ♀, Mexico, Baja California Norte, 11.5 mi SW San Miguel de Comondu (SDNH).

scape, curved medially to partially conceal triangular shaped projection; a median scale tuft from base of triangular shaped projection, extending over projection. Female vertex with flat scales arranged in a triangular pattern. Antenna filiform; setose ventrally. Proboscis well developed. **Thorax:** Smoothly scaled. Proleg with epiphysis present on tibia, less than half length of tibia. Mesotibia with elongate (more than 3/4 length of tibia) hair pencil arising from a specialized scale patch laterad at proximal apex, hair pencil enclosed in a laterad elongate groove (Fig. 6); spines absent; spurs with shortest less than half length of longest. Mesotibia with 2 pairs of tibial spurs; proximal pair with shortest more than half length of longest; distal pair with shortest less than half length of longest; spines absent. **Forewing:** Length 12–19 mm. Vein R1 from discal cell, ending on costal margin; R2 and R3 + 4 from areole; R2 ending on costal margin; R3 and R4 long stalked, ending on costal margin; R5 from areole, connate with R3 + 4, ending on outer margin; M1 from upper angle of discal cell; M2 and M3 from anal angle of discal cell; M3 nearer M2 than CuA1. **Hindwing:** Length 10–13 mm. Vein Sc + R1 to apex; Rs and M1 connate; M2 present well developed from anal angle of discal cell; M3 and CuA1 connate; 2A and 3A present. **Ab-**

**domen:** Smooth scaled. Male with seventh tergite with a small, median, pointed projection on proximal margin. Eighth tergite with a narrow X-shaped tergite, remainder membranous (Fig. 31). Eighth sternum with a wine glass shaped sternite that forms a small triangle at proximal end bearing a pair of tenuis lateral arms and a median elongate arm extending dorsad into wide intersegmental membrane, remainder membranous (Fig. 32); a pair of elongate coremata from lateral arms, bifurcate and covered with fine hairs (Fig. 33). Female abdomen without modifications. **Male Genitalia:** Uncus well developed, base broader than apex, lateral setae at middle. Scaphium as long as uncus well sclerotized. Subscaphium well developed, narrower than scaphium, striate. Valva elongate, narrow, length greater than 6 times width. Cucullus truncate and not as sclerotized as valva. Sacculus well developed, extends beyond apex of valva; costal lobe prominent; apex produced into a dorsally curved spine. Juxta well developed, excavated dorsad. Clasper, ampulla, and valvula absent. Aedoeagus slender, well sclerotized. Vesica well developed with multiple diverticula, spines, and cornuti of two types, (1) variously sized, spinelike and (2) elongate, hairlike. **Female Genitalia:** Seventh sternite indented medially at apex, with or without a median





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FIGS. 25–30. Adults of *B. deducta*. 25, ♂, Arizona, Cochise Co., Peloncillo Mts., Guadalupe Canyon (USNM). 26, ♀, Arizona, Cochise Co., Cherry Canyon, near Cherry (USNM). 27, ♀, Texas, Cameron Co., San Benito (USNM). 28, ♀, Texas, Brewster Co., Alpine (USNM). 29, ♀, Arizona, Cochise Co., Huachuca Mts., Ash Canyon Road (USNM). 30, ♀, Texas (USNM).

prong. Ostium at apex of seventh sternite. Eighth segment telescopes inside seventh. Eighth sternite not joined medially. Segment 9 and 10 membranous and longer than segment 8. Apophyses posteriores elongate, extending beyond proximal margin of segment 8. Apophyses anteriores elongate, extending to or beyond middle of segment 7. Papillae analis sparsely setose, apex produced.

**Discussion.** The only species in *Bulia* that can be readily separated from the others is *B. confirmans*, with its small size and white anal lunule in the hindwing. All other species of *Bulia*, with the yellow anal lunule in the hindwing, can only be identified by genitalic characters.

Other species with which *Bulia* species potentially can be confused are *Drasteria eubapta* Hampson, *D.*

*fumosa* (Strecker), *D. pallescens* (Grote & Robinson), *Forsebia perlaeta* (H. Edwards), *Melipotis novanda* (Guenée), and *M. indomita* (Walker).

#### KEY TO SPECIES

1. Hindwing with anal lunule white (Figs. 9–10) . . . . *confirmans*
- 1'. Hindwing with anal lunule yellow (Figs. 11–30) . . . . . 2
2. Head with large median projection of vertex, can be concealed by hairlike scale tufts; (Fig. 3); apical segment of labial palpus short and partially concealed by scales of middle segment (Fig. 7); male . . . . . 3
- 2'. Head without large median projection of vertex, scales flat not tufted; apical segment of labial palpus long and not concealed by scales of middle segment (Fig. 8); female . . . . . 6
3. Juxta with dorsal margin V-shaped; lateral projections scobinate, pointed and heavily sclerotized (Figs. 38 and 43) *deducta*

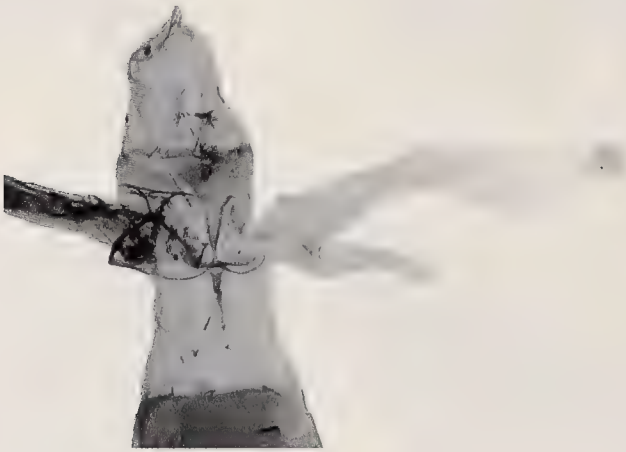




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FIGS. 31–33. Structures associated with the abdomen. **31**, ♂, Eighth abdominal sternite of *B. confirmans* (genitalia slide USNM 46368). **32**, ♂, Eighth abdominal tergite of *B. confirmans* (genitalia slide USNM 46368). **33**, ♂, Coremata of *B. similis* (genitalia slide USNM 46332).

- 3'. Juxta with dorsal margin U-shaped, lateral projections absent (Figs. 35–37 and 40–42) ..... 4
- 4. Vesica with a single large spine (Fig. 46) ..... *schausi*
- 4'. Vesica with two large spines (Figs. 45 and 47) ..... 5
- 5. Costal lobe of sacculus small, triangulate (Fig. 35); disto-lateral diverticulum elongate, more than twice length of apical spine (Fig. 45); base of vesica lacking small pair of ventral diverticula (Fig. 45) ..... *mexicana*
- 5'. Costal lobe of sacculus large, truncate to triangulate (Fig. 37); disto-lateral diverticulum short, less than twice length of apical spine (Fig. 47); base of vesica with a pair of small ventral diverticula (Fig. 47) ..... *similis*
- 6. Seventh sternite with median prong elongate, extending above apex of lateral prolongation (Figs. 53 and 58) ..... *deducta*
- 6'. Seventh sternite with median prong short, extending to or below apex of lateral prolongation (Figs. 50–52 and 55–57) ..... 7
- 7. Corpus bursae with two sclerotized structures, (1) an elongate curved process with pointed apex at base of ductus seminalis, (2) ventral to 1 a sclerotized area with a curved apex pointed in the opposite direction of 1 (Fig. 51) ..... *schausi*
- 7'. Corpus bursae lacking large sclerotized structures (Figs. 50 and 52) ..... 8

- 8. Seventh sternite with median prong short, height less than width (Fig. 55) ..... *mexicana*
- 8'. Seventh sternite with median prong elongate, height greater than width (Fig. 57) ..... *similis*

*Bulia confirmans* (Walker)  
(Figs. 2–6, 9–10, 31–32, 34, 39, 44, 49, 54, 59)

*Bolina confirmans* Walker [1858] 1857:1157.

*Bolina umbrosa* Walker [1858] 1857:1158. [Synonymized by Richards 1936a:433.]

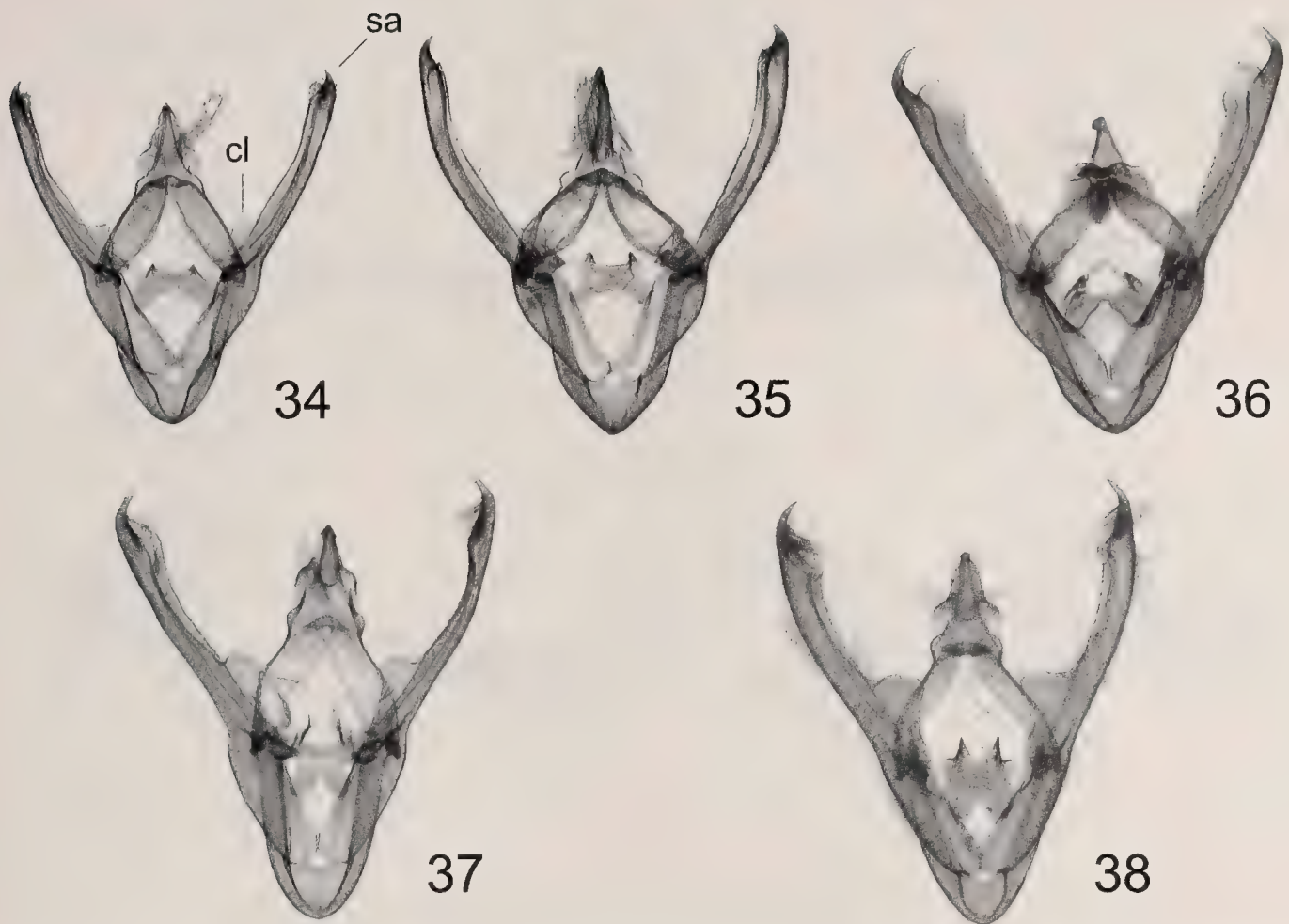
*Biula propira* Walker [1858] 1857:1170. [Synonymized by Richards 1936a:433.]

*Arsisaca bolinalis* Walker [1866] 1865:262, **new synonym.**

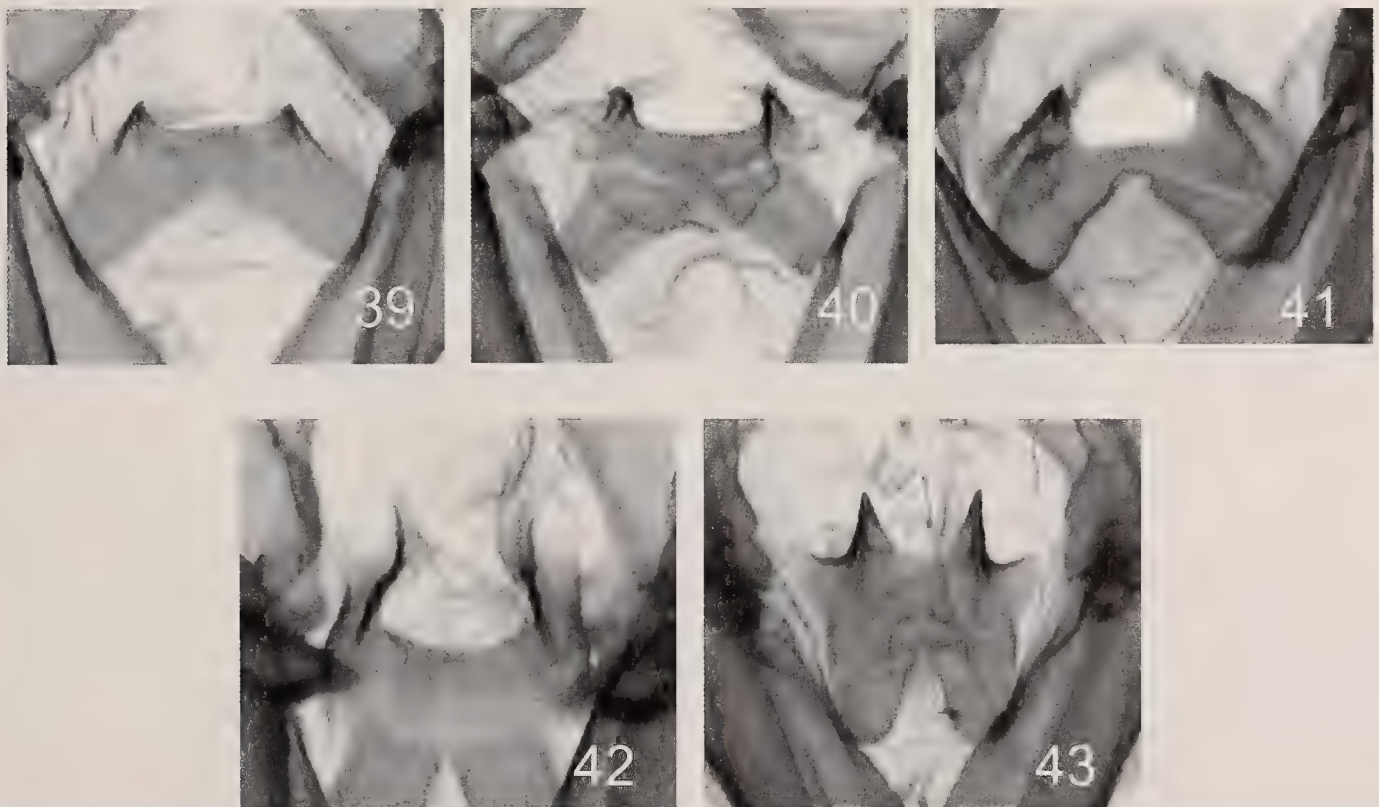
*Bulia bolinalis*, Poole 1989:180.

*Bulia confirmans*, Richards 1936a:433; Richards 1939:pl. V, Figs. 7–9; Richards 1941:258; Poole 1989:180.





FIGS. 34–38. Male genitalia. **34**, *B. confirmans* (genitalia slide USNM 46366). **35**, *B. mexicana* (genitalia slide USNM 46333). **36**, *B. schausi* (genitalia slide USNM 46362). **37**, *B. similaris* (genitalia slide USNM 46323). **38**, *B. deducta* (genitalia slide USNM 46322), cl = costal lobe of sacculus, sa = sacculus apex.



FIGS. 39–43. Male juxta. **39**, *B. confirmans* (genitalia slide USNM 46366). **40**, *B. mexicana* (genitalia slide USNM 46333). **41**, *B. schausi* (genitalia slide USNM 46362). **42**, *B. similaris* (genitalia slide USNM 46323). **43**, *B. deducta* (genitalia slide USNM 46322).





FIGS. 44–48. Male aedoeagus. **44**, *B. confirmans* (genitalia slide USNM 46366). **45**, *B. mexicana* (genitalia slide USNM 46333). **46**, *B. schausi* (genitalia slide USNM 46362). **47**, *B. similaris* (genitalia slide USNM 46323). **48**, *B. deducta* (genitalia slide USNM 46322).

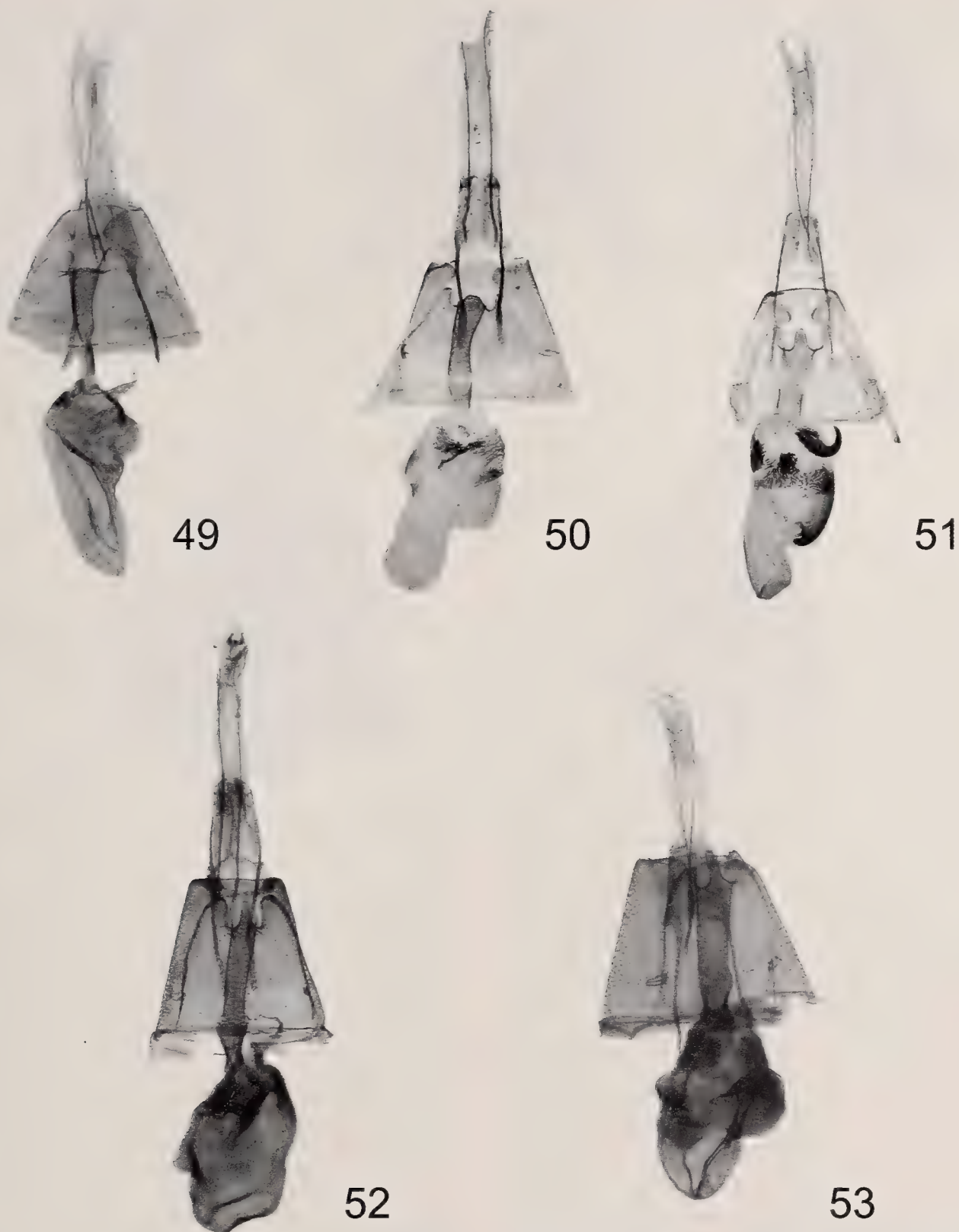
**Diagnosis.** This is the most easily recognized species of *Bulia*. It is the only one with a white lunule on the hindwing, all other *Bulia* have a yellow lunule.

**Description. Adult male. Head:** Frons white with light brown scales. Vertex light brown. Labial palpus with basal segment mostly white with some brown scales laterally; middle and apical segments brown with some white. Antennal scape brown, light brown laterally; scaled dorsally, setose ventrally, setae approximately width of antennal segments. **Thorax:** Patagium, mesothorax, and metathorax light brown. Prothoracic femur brown with some white scales; tibia brown with an indistinct median white band, apical band white; tarsi brown with white apical rings. Mesothoracic femur white speckled with brown; tibia brown speckled with white; tarsi brown with white apical rings. Metathoracic femur white speckled with brown; tibia brown speckled with white dorsally, white ventrally, a tuft of scales below proximal apex buff; tarsal segment 1 brown and white, with white apical ring, rest brown speckled with white, white apical rings. Underside white. **Forewing:** Length 11.5–13.5 mm. Basal patch light brown; costal margin brown; basal band brown to M vein; me-

dian line black to R vein; median band cream to middle of discal cell, speckled with brown to costal margin; orbicular spot a small black patch; two indistinct whitish scale patches beyond orbicular spot; reniform spot cream; postmedial line black from posterior margin, angled back toward outside of median band and bordering outside of reniform spot to its apex; postmedial band brown; subterminal line buff from termen to M1 cell; terminal line black, scalloped, from termen to M1 vein. Underside ground color white; brown patch at end of discal cell; brown band on terminal third. **Hindwing:** Ground color white; band on terminal fourth brown; white spot at apex of CuA1 cell. Underside as in upperside; white apical spot larger. **Abdomen:** Light brown dorsally; white ventrally. **Genitalia** (Figs. 34, 39, 44): Sacculus with costal lobe triangular; apex a short projection. Juxta with U-shaped dorsal margin. Aedoeagus without dorsal spiculations near apex. Vesica with a large and a small spine; numerous minute cornuti. (All attempts at inflating vesica failed.)

**Adult female.** Essentially as described for male except: **Forewing:** Length 13.0–14.5 mm. Basal patch brown speckled with white and light brown; median band indistinct, speckled with light





FIGS. 49–53. Female genitalia. **49**, *B. confirmans* (genitalia slide USNM 46367). **50**, *B. mexicana* (genitalia slide USNM 46378). **51**, *B. schausi* (genitalia slide USNM 46379). **52**, *B. similaris* (genitalia slide USNM 46325). **53**, *B. deducta* (genitalia slide USNM 46327).

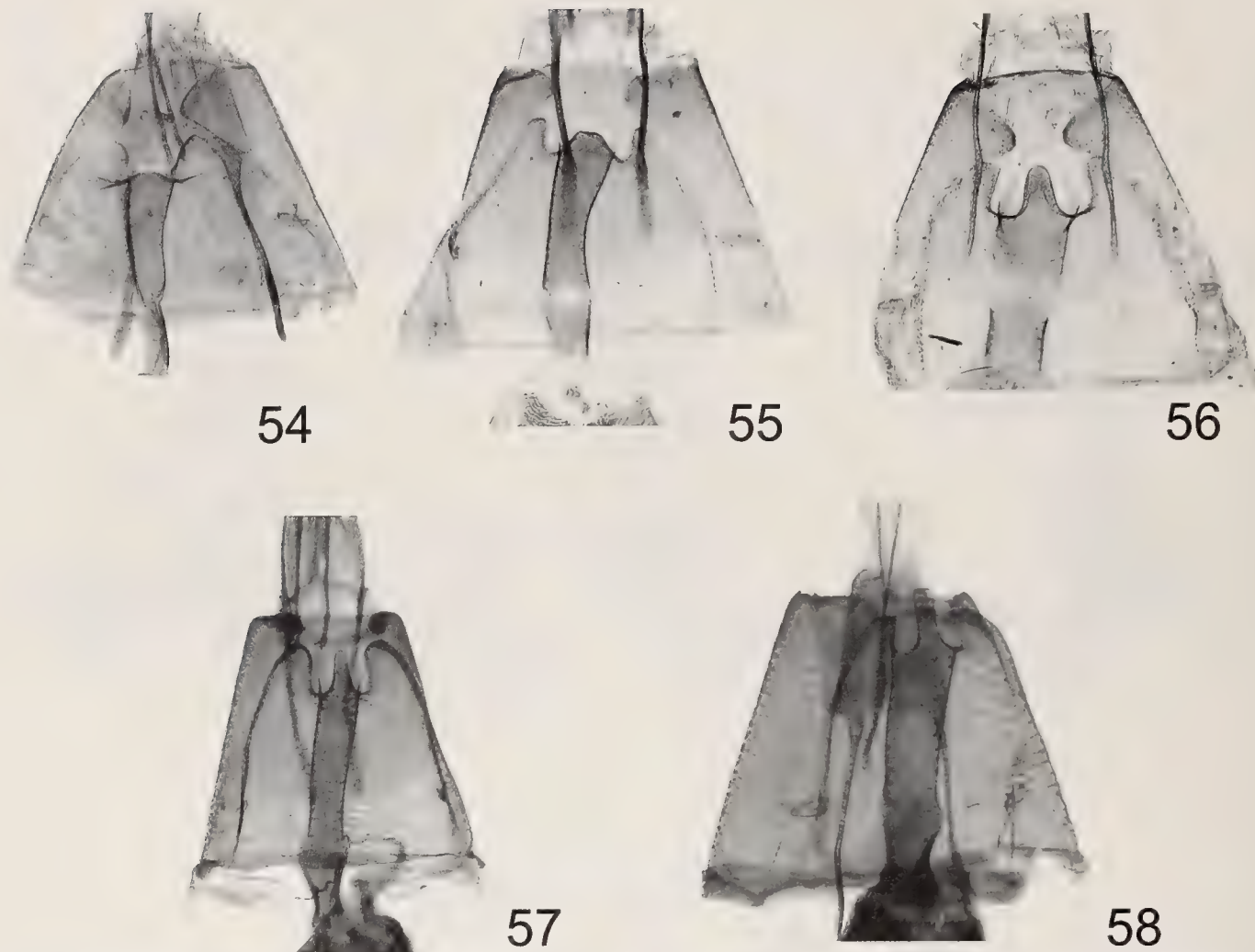
brown, white, and brown; reniform spot speckled with light brown, white, and brown; subterminal line from termen to costa; terminal line from termen to costa. **Abdomen:** Underside white, pale brown to buff at apex. **Genitalia** (Figs. 49, 54): Seventh segment deeply invaginated; median prong absent.

**Type material.** *Bolina confirmans* Walker; holotype ♀, St. Domingo [Dominican Republic], in BMNH. *Bolina umbrosa* Walker; holotype ♀, St. Domingo [Dominican Republic], in BMNH.

*Biula propira* Walker; holotype ♂, St. Domingo [Dominican Republic], in BMNH. *Arsisaca bolinalis* Walker; holotype ♂, Jamaica, in BMNH.

**Material examined.** 47 ♂ and 102 ♀. All material is from the USNM unless otherwise noted. **COLOMBIA:** ATLANTICO: Cuatro Bocas, 22 Jan. 1959, J.F.G. Clarke, 1 ♂. **CUBA:** No specific locality, 2 ♀; Santiago, 1 ♂, 1 ♀. **CURACAO:** 3 km NE Willemstad, 8–15 Feb. 1987, 1 ♀, 13 Feb. 1987, 2 ♀, W.E. Steiner & J.M.





FIGS. 54–58. Female ventral plate of ostium bursa. **54**, *B. confirmans* (genitalia slide USNM 46367). **55**, *B. mexicana* (genitalia slide USNM 46378). **56**, *B. schausi* (genitalia slide USNM 46379). **57**, *B. similaris* (genitalia slide USNM 46325). **58**, *B. deducta* (genitalia slide USNM 46327).

Swearingen; 3 km NW Fuik, 11 Feb. 1987, W.E. Steiner & J.M. Swearingen, 1 ♂. **DOMINICAN REPUBLIC:** LA VEGA PROVINCE: Constanza, Hotel Nueva Suiza, 1164m, 29 May 1973, D. & M. Davis, 1 ♂, 1 ♀. MONTE CRISTI PROVINCE: 10 km S Monte Cristi, 5 m, 23 May 1973, D. & M. Davis, 10 ♂, 36 ♀; Los Hidalgos, 4–5 June 1969, Flint & Gomez, 6 ♀; Mt. Cristy, Santo Domingo, Atwater, 1 ♀; Santo Domingo, Atwater, 1 ♂. **GRENADA:** Hardy Bay, 26 Oct.–4 Nov. 1975, E.L. Todd, 2 ♂, 3 ♀; Lance aux Epines, 30 Oct. 1975, E.L. Todd, 1 ♀. **HAITI:** No specific locality, 1 ♂. **JAMAICA:** No specific locality, Col. B. Neumogen, 2 ♂, 1 ♀, Collection J.B. Smith, 1 ♂, 1 ♀, Collection Wm Schaus, 3 ♀, Collection Brklyn Mus, 1 ♀, Col. E.L. Graef, 1 ♂, 1 ♀. **CLARENDON PARISH:** 2 km S Rocky Pt., nr. Jackson Bay Cave, 5 m, 10 Dec. 1975, D. & M. Davis, 1 ♂, 1 ♀; Portland Ridge, nr. Jackson Bay Cave, 40 ft., 4 May 1973, D. & M. Davis, 6 ♂, 7 ♀, ♀ genitalia slide USNM 46367; ST. ANDREW PARISH: Upper Mt. View, July 1942, 2 ♀, July 1948, 1 ♀, Aug. 1942, 1 ♂, ♂ genitalia slide USNM 46366, C.B. Lewis. **ST. ANN PARISH:** nr. Runaway Bay Cave, 50 ft., 1–2 May 1973, D. & M. Davis, 1 ♀; Hill Gardens, 14 June 1923, C.O. Gowdy, 1 ♂; Kingston, about 70 ft., 4–10 Dec. 1910, 1 ♂ (AMNH); Mandeville, Manchester, about 2250 ft., 18–20 Jan. 1920, 1 ♂ (AMNH); Port Royal, 27 Feb. 1911, 1 ♀ (AMNH). **PUERTO RICO:** Isla Maguay, Parguera, 20 Dec. 1962, P. & P. Spangler, 2 ♀. **VENEZUELA:** ARAGUA: Rancho Grande, 1100 m, cloud forest, 30–31 Mar. 1978, J.B. Heppner, 1 ♀. LARA: El Cuji, 7 mi N Barquisimeto, 29 June–1 July 1967, R.W. Poole, 1 ♀; Puente Torres, 24 km E Carora, 10 Mar. 1978, thorn forest, J.B. Heppner, 9 ♂, 16 ♀, ♂ genitalia slide USNM 46368. **MERIDA:** Río

Chama Valley, 12 km SW Ejido, 4000 ft., dry forest, 17 Feb. 1978, J.B. Heppner, 1 ♂, 7 ♀. **ZULIA:** El Tucuco, Sierra de Perijá, montane forest, 28–29 Jan. 1978, J.B. Heppner, 2 ♀. **Isla de Margarita, Nueva Esparta**, 23 June 1997, R. Segura, stem borer *Jatropha gossypifolia*, 1 ♂; Valera, E.P. de Ballard, 1 ♂; Valera, Trujillo, Nov. 1922, H. Pittier, 1 ♂.

**Larval host.** *Jatropha gossypifolia* (L.) (Euphorbiaceae). This species is considered a noxious weed in Puerto Rico (GRIN Database 2000). The distribution of *J. gossypifolia* is from Mexico south to Honduras and Nicaragua, throughout the Caribbean to Venezuela and Colombia south to Ecuador and Brazil. *Bulia confirmans* completely overlays this distribution. The single specimen reared was from Isla de Margarita, Nueva Esparta, Venezuela.

**Distribution** (Fig. 59). Collections from the Caribbean include localities in Cuba, Jamaica, Haiti, Dominican Republic, Puerto Rico, Grenada, and Curaçao and in South America from northern Venezuela and Colombia.

**Discussion.** The female of *B. confirmans* is more variable in maculation than the male. Specimens from the Dominican Republic and Jamaica show a pattern (Fig. 10), which is less distinct, but has all of the pattern elements that are present in the male. In Venezuela the patterned female is present, but uncommon. The most common female there is completely without pattern, except for a black orbicular spot and terminal line. The ground color is brown.





FIG. 59. Known localities from collections of *B. confirmans* (solid circles), *B. mexicana* (open squares), *B. schausi* (solid triangles).

An adult specimen of *B. confirmans* was sent to the senior author for identification as a possible biological control agent for *J. gossypiifolia*.

*Bulia mexicana* (Behr)  
(Figs. 11–14, 35, 40, 45, 50, 55, 59)

*Syneda mexicana* Behr 1870:26.

*Bulia mexicana*, Richards 1936a:433; Richards 1941:258; Poole 1989:180.

**Diagnosis.** The remaining species of *Bulia* are almost indistinguishable from each other except for characters in the male and female genitalia. *Bulia mexicana* is separated from the other species by the following combination of characters in the male genitalia (Fig. 35): (1) juxta U-shaped; (2) sacculus lobe small, triangular; (3) aedeagus with external spiculations absent; and (4) disto-lateral diverticulum longer than aedeagus. The most closely related species to *B. mexicana* is *B. schausi*, but the females of *B. mexicana* can be differentiated from the females of *B. schausi* by the absence of any heavily sclerotized areas in the corpus bursae (compare Figs. 50 and 51); and females of *B. mexicana* can be separated from females of *B. similaris* and *B. deducta* by the median prong of the seventh segment being wider than high in *B. mexicana* (compare Figs. 50 and 57–58).

**Description. Adult male. Head:** Frons white with light brown scales. Vertex light brown. Labial palpus with basal segment mostly white with some light brown scales laterally; middle and apical segments light brown with some white. Antennal scape brown, white laterally; scaled dorsally, setose ventrally, setae approximately width of antennal segments. **Thorax:** Patagium, mesothorax, and metathorax brown. Prothoracic femur brown with some white scales; tibia brown with some white scales, apical band white; tarsi brown with white apical rings. Mesothoracic femur white speckled with brown; tibia with equal amounts of brown and white; tarsi brown with white apical rings. Metathoracic femur white speckled with brown; tibia with equal amounts of brown and white, white ventrally, a tuft of scales below proximal apex buff; tarsal segment 1 brown and white, with white apical ring, rest brown speckled with white, white apical rings. Underside white. **Forewing:** Length 14.0–16.0 mm. Basal patch brown; costal margin brown; basal band black to M vein; median line black to R vein; median band cream to middle R vein, light



FIG. 60. Known localities from collections of *B. similaris*.

brown to costal margin; orbicular spot a small black patch; two indistinct whitish to pale gray scale patches beyond orbicular spot; reniform spot cream; postmedial line black from posterior margin, angled back toward outside of median band and bordering outside of reniform spot to its apex; postmedial band brown with pale gray median stripe; subterminal line cinnamon from termen to M1 cell; terminal line black, scalloped, from termen to apex. Underside ground color cream; wide brown patch at end of discal cell from R to 1A + 2A vein; brown band on terminal third. **Hindwing:** Ground color light brown; band on terminal two-fifths brown; lunule yellow. Underside ground color cream; small brown spot in middle of discal cell; brown terminal band; lunule cream. **Abdomen:** Light brown dorsally; white ventrally. **Genitalia** (Figs. 35, 40, 45): Sacculus with costal lobe triangular; apex a short projection. Juxta with U-shaped dorsal margin. Aedeagus without dorsal spiculations near apex. Vesica with a small spine at apex of lateral diverticulum, disto-lateral diverticulum longer than aedeagus with large apical spine; numerous minute cornuti on all diverticula except lateral.

**Adult female.** Essentially as described for male except: **Forewing:** Length 15.0–17.0 mm. Basal patch light brown speckled with brown; basal band black, thin, same width as postmedial line; median band light brown, speckled with brown; reniform spot light brown speckled with brown; subterminal line faint, from termen to costa. **Abdomen:** Light brown speckled with brown. Underside white speckled with brown, buff at apex. **Genitalia** (Figs. 50, 55): Seventh segment deeply invaginated; median prong short, width greater than height, does not extend above lateral projections. Corpus bursa with basal spicules larger than rest.

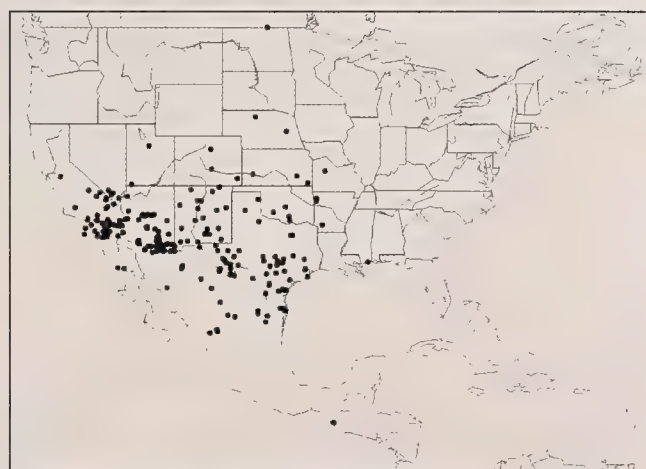


FIG. 61. Known localities from collections of *B. deducta*.



**Type material.** *Bolina mexicana* Behr; neotype ♂, Mexico, Sinaloa, Mazatlan, in USNM [designated by Richards 1936a].

**Material examined.** 20♂ and 26♀. All material is from the USNM unless otherwise noted. **COSTA RICA:** GUANACASTE: Area de Conservación Guanacaste, Sector Santa Rosa, Estero Naranjo, 2♂, 13 Jan. 1997, 97-SRNP-87, 97-SRNP-92, 2♂, 97-SRNP-85, 97-SRNP-88, 97-SRNP-91, 97-SRNP-97.1, 4♀, 23 Jan. 1997, 97-SRNP-219, 1♀; Playa Naranjo, Santa Rosa P.N., Mar. 1991, INBIOCR1000674402, INBIOCR1000674399, 2♀, May 1991, 1♀, INBIOCR1000386796, Dec. 1990, INBIOCR1000514740, 1♀, E. Alcazar; R. San Lorenzo, R.F. Cord., (Tenorio), 1050m, June 1991, INBIOCR1000610645, C. Alvarado, 1♀; Santa Rosa National Park, 1–3 June 1979, INBIOCR1002581940, D.H. Janzen, 1♀. PUNTARENAS: Est. San Miguel, Punta San Miguel, 1♂, 2 Oct. 1997, INBIOCR1002561384, F. Alvarado, 1♀ (INBIO). Avangarez, July, 1♂, ♂ genitalia slide USNM 46377, Schaus and Barnes Coll., June, 1♀, ♀ genitalia slide USNM 46378, Wm. Schaus Coll. **MEXICO:** CHIAPAS: SE Tonalá, 5 June 1969, 2♂, 5♀, ♀ genitalia slide MGP # 1128, A. Mutuura (CNC). COLIMA: Cuyutlan, Jan., C.C. Hoffmann, 1♂, 1♀ (AMNH). JALISCO: Estación de Biología, Chamela, 23–24 Feb. 1981, 1♂, 24–27 May 1982, 1♂, 5/12/1980, 1♂, 1–3 Dec. 1981, 1♂, A. Pescador, 1–2 May 1976, 1♂, C. Beutelspacher (UNAM); Navidad, 1 Apr. 1939, A.H. & S.H. Rinde, ♀ on genitalia slide 3622, 1♀ (AMNH). NAYARIT: 5 mi E San Blas, 24–26 Apr. 1961, Howden & Martin, 4♀; Nuevo Vallarta, 27 Dec. 1988, A.D. Warren, 1♀ (CSU). OAXACA: Tehuantepec, 15–16 July 1964, 2♂, P.J. Spangler, 11 July 1955, Vaurie, 1♀, ♀ on genitalia slide 8760 (AMNH). SINALOA: Mazatlan, 17–23 July 1963, P.J. Spangler, 1♂, 2♀, ♂ genitalia slide USNM 46333, 9 May 1961, 2♂, 10 May 1961, 1♂, 7♀, ♀ genitalia slide MGP # 1127, Howden & Martin (CNC), 22 July 1954, 1♂, M. Casier, W. Gertsch, Bradts (AMNH).

**Larval host.** Specimens were reared on *Prosopis juliflora* (Sw.) DC. (Fabaceae) from Area de Conservación Guanacaste, Sector Santa Rosa, Estero Naranjo, Guanacaste Province, Costa Rica. It is considered a noxious weed species in Puerto Rico and Hawaii (GRIN Database 2000). Data for these rearings can be found on the Caterpillar Rearing Voucher Databases for the Area de Conservación (ACG) in northwestern Costa Rica (Janzen 2000).

**Distribution** (Fig. 59). Collections of *B. mexicana* are from west central Mexico along the Pacific coast to Chiapas and northwestern Costa Rica.

**Discussion.** The overall shade of the color pattern can vary between light and dark. This also occurs in specimens of *B. similaris* from Mexico. There are two forms in the female forewing color pattern. The maculate form shows all of the color pattern elements that are present in the male, but not as distinct, giving these specimens a washed out appearance. The immaculate form is almost completely lacking a pattern, except for the faint subterminal and terminal lines, the small black subapical spot and the large dark reniform spot.

*Bulia schausi* Richards

(Figs. 15–18, 36, 41, 46, 51, 56, 59)

*Bulia schausi* Richards 1941:259; Poole 1989:180.

**Diagnosis.** *Bulia schausi* tends to be grayer in ground color than *B. mexicana*, but dissection is nec-

essary for accurate identification. The differences in the male genitalia of *B. schausi* from other species of *Bulia* are the costal lobe of the sacculus is slightly bifurcate (Fig. 36) and the vesica bears a single spine (Fig. 46). In the female genitalia, these differences are the corpus bursa has a heavily sclerotized cone within the ductus seminalis and ventral to this is a heavily sclerotized area that ends in a blunt apex (Fig. 51).

**Description. Adult male. Forewing:** Length 15.0–16.5 mm. **Genitalia** (Figs. 36, 41, 46): Sacculus with costal lobe slightly bifurcate; apex an elongate projection. Juxta with U-shaped dorsal margin. Aedoeagus without dorsal spiculations near apex. Vesica with lateral diverticulum absent, disto-lateral diverticulum with large apical spine and minute cornuti at base of disto-lateral diverticulum, cornuti larger on ventro-proximo lateral diverticula.

**Adult female. Forewing:** Length 15.5–16.0 mm. **Genitalia** (Figs. 51, 56): Seventh segment deeply invaginated; median prong short, width greater than height, extends to lateral projections. Corpus bursa with heavily sclerotized cone within the ductus seminalis; ventral to this is a heavily sclerotized area ending in a blunt apex; a band of elongate spicules between these two areas.

**Type material.** *Bolina schausi* Richards; holotype ♂, Mexico, Tehuacan, in USNM.

**Material examined.** 12♂ and 10♀. All material is from the USNM unless otherwise noted. **MEXICO:** DISTRICTO FEDERAL: Ajusco, 3000m, 1 June 1981, 1♀, C. Beutelspacher (UNAM); Chapultepec, 20 June 1939, 1♀, C. Beutelspacher (UNAM); Jardín Botánico, C.U., 5 Nov. 1969, C. Beutelspacher (UNAM); Xochimilco, 3 July 1983, 1♂, C. Beutelspacher (UNAM); 18 June 1963, 1♂, 21 June 1963, 1♀, 12 July 1960, 1♂, R. Johnson (UNAM). DURANGO: 10 mi W Durango, 15 June 1964, W.C. McGuffin, (1♀) (CNC); 7 mi W Durango, 26 July 1964, 1♂, ♂ genitalia slide MGP # 1132, W.C. McGuffin (CNC); El Salto, Rcho. Nuevo, 10–13 June 1989, Broomfield, 1♂ (SDNH); Vte. Gro., 3 June 1984, 1♂, 1♀ (UNAM). MEXICO: 7 air mi WSW Juchitepec, 275m, 24 Aug. 1987, J. Brown & J. Powell, 1♀ (UCB). PUEBLA: Tehuacán, Sep. 1908, Muller, 1♀, paratype, ♀ genitalia slide USNM 46379; Sep. 1937, ♀ on genitalia slide 3612, 20 May 1941, ♂ on genitalia slide 3501, 1♂, 1♀ (AMNH). SONORA: 16 mi NE Cd. Obregon, 13–17 May 1961, Howden & Martin, 1♂, ♂ genitalia slide MGP# 1131 (CNC). VERACRUZ: Fortin, 7 June 1988, T. Taylor, 1♂ (CSU); Orizaba, 2♂, ♂ genitalia slide USNM 46380, 2♀, ♀ genitalia slides USNM 46381, 46382.

**Larval host.** Unknown.

**Distribution** (Fig. 59). Collections from northwest to east central Mexico. Localities are near or in the Sierra Madre Occidental.

**Discussion.** This is the rarest species of *Bulia*. The sexual dimorphism in the female is the immaculate form in which there is virtually no pattern and the reniform spot is large and dark.

*Bulia schausi* is associated with the mountainous central region of Mexico. It is sympatric with *B. similaris* in the vicinity of Tehuacan, Puebla, Mexico.

*Bulia similaris* Richards

(Figs. 19–24, 33, 37, 42, 47, 52, 57, 60)

*Bulia similaris* Richards 1936a:433; Richards 1941:262; Poole 1989:180; Poole and Gentili 1996:729.



*Bulia similaris* race *californica* Richards 1939:70; 1941:262. [Synonymized by Poole 1989:80.]

*Bulia morelosa* Richards 1941:261; Poole 1989:180, new synonym.

**Diagnosis.** *Bulia similaris* is most closely related to *B. deducta*, but can be separated by the shape in the juxta in the male genitalia. The juxta in *B. similaris* has a U-shaped dorsal margin (Fig. 42), whereas the juxta in *B. deducta* has a V-shaped dorsal margin (Fig. 43). The elongate apex of the sacculus is round in *B. similaris* (Fig. 37), but pointed in *B. deducta* (Fig. 38). The spiculations near the apex of the aedoeagus are larger and cover a smaller area in *B. similaris* (Fig. 47), in *B. deducta* the spiculations are smaller and cover a larger area (Fig. 48). The cornuti on the disto-lateral diverticulum are smaller and greater in number in *B. similaris* (Fig. 47) than in *B. deducta* (Fig. 48). The females can be separated by the shape of the median prong of the seventh abdominal segment. The prong width is greater than its height in *B. mexicana* and *B. schausi* (Figs. 55–56), but in *B. similaris* and *B. deducta* the height is greater than the width (Figs. 57–58). In *B. similaris* the length of the median prong is less than or equal to the height of the lateral projections (Fig. 57); in *B. deducta* the median prong is greater than the height of the lateral projections (Fig. 58).

**Description. Adult male. Forewing:** Length 13.0–16.5 mm. **Genitalia** (Figs. 37, 42, 47): Sacculus with costal lobe triangular with a rounded apex; apex an elongate projection. Juxta with U-shaped dorsal margin. Aedoeagus with dorsal spiculations near apex. Vesica with largest spine on lateral diverticulum, smallest spine on disto-lateral diverticulum; minute cornuti ventral and lateral on disto-lateral diverticulum and ventro-lateral diverticula; ventro-proximal diverticula absent; largest cornuti dorsally on disto-lateral diverticulum; an extra pair of small ventral diverticula at base of vesica.

**Adult female. Forewing:** Length 12.5–18.0 mm. **Genitalia** (Figs. 52, 57): Seventh segment deeply invaginated; median prong width less than or equal to height, extending to or below lateral projections, apex truncate or with slight V-shaped notch. Corpus bursa with dorso-medial invagination lightly sclerotized and containing fine spicules; a band of elongate spicules below junction with ductus bursae.

**Type material.** *Bolina similaris* Richards; holotype ♂, U.S.A., Texas, San Benito, in USNM.

**Material examined.** 203 ♂ and 244 ♀. All material is from USNM unless otherwise noted. **MEXICO:** BAJA CALIFORNIA [label data]: Las Parras, W.M. Mann, 1 ♂; Punta Prieta, 27 Mar. 1935, V.H. dos Passos, 1 ♀; 23 mi S San Ignacio, 10 Oct. 1967, G.A. Marsh, 1 ♀ (UCB); Desengano, 9 Oct. 1962, F.T. Thorue, 1 ♀ (UCB); L. Cantilla Cyn., Sierra Juarez, 20 Mar. 1967, P.A. Opler & J. Powell, 2 ♀ (UCB); San Felipe, 26 Mar. 1963, G.J. Stage, 2 ♂ (UCB); Canyon del Tajo, 1 Apr. 1953, J. Powell, 3 ♂, 6 ♀ (UCB); 17 mi N Punta Prieta, 3 Oct. 1961, C.F. Harbison, 1 ♂ (SDNH); 20 mi N Punta Prieta, 27 Apr. 1962, C.F. Harbison, 1 ♂ (SDNH); 8 mi N El Refugio Magdalena, 19 Oct. 1961, F.F. Gander, 1 ♂, 2 ♀ (SDNH); Agua Refugio, 1 Apr. 1935, C.F. Harbison, 1 ♀ (SDNH); Cautiles (Tajo Canyon), 20 Apr. 1955, C.F. Harbison, 1 ♀ (SDNH); Mesquital, Apr. 1928, 1 ♂ (SDNH); Santiago,

1952, C.F. Harbison, 1 ♂ (SDNH); 15 Nov. 1936, F. Gander, 1 ♂ (SDNH). BAJA CALIFORNIA NORTE: 14.4 mi S Campo Alfonsina, 20–26 Oct. 1987, N. Bloomfield, 1 ♂, ♂ genitalia slide USNM 46364; 14.4 mi S Campo Alfonsina, 20–26 Oct. 1987, N. Bloomfield, 1 ♂, ♂ genitalia slide USNM 46364; 59 mi S Puertecitos, 14–15 Mar. 1988, N. Bloomfield, 1 ♂, ♂ genitalia slide USNM 46363; Rancho Santa Ines, 540 m, 30 June 1979, W.H. Clark, 2 ♂, 3 ♀; 10 mi SE El Rosario, 31 Mar. 1976, J. Doyen, P. Rude, R. Morrison, 1 ♂, 2 ♀ (UCB); 24 mi N Punta Prieta, 1–2 Apr. 1973, S.L. Szerlip, J. Doyen, J.A. Powell, 1 ♀, 1 Apr. 1973, 1 ♀, S.L. Szerlip, 2 Apr. 1973, 1 ♀, J.A. Powell (UCB); 7 mi SW Mission San Borja, 30 Mar. 1973, J.A. Powell, 1 ♀ (UCB); 9 km NW Rancho Santa Ines, 550m, 1 July 1979, W.H. Clark, 1 ♂, 1 ♀ (CNC); Arroyo Catavina, 35 mi S El Progreso, 2 Apr. 1976, Doyen & Rude, 2 ♀ (UCB); Bahia los Angeles, 26 Dec. 1978, R.E. Dietz, 1 ♂ (UCB); Diablito Cyn., E face Sierra San Pedro Martir, 5–6 Apr. 1973, J.A. Powell, 1 ♂ (UCB); 1.2 mi E Santa Ines (arroyo), 23 Mar. 1986, Faulkner & Broomfield, 2 ♀ (SDNH); 1.2–5.4 mi S Santa Ines, 5–9 Dec. 1987, N. Broomfield, 3 ♂, 5 ♀ (SDNH); 1.5 mi SW San Miguel, 16–20 Dec. 1987, N. Broomfield, 4 ♂, 6 ♀ (SDNH); 10.2 mi W Ranch Progreso (S. Francisquito), 6–7 Nov. 1987, N. Broomfield, 2 ♂ (SDNH); 11.5 mi SW San Miguel de Comondu, 15 Dec. 1987, N. Broomfield, 3 ♂ (SDNH); 12 mi N Catavina, 30 Apr. 1962, C.F. Harbison, 1 ♀ (SDNH); 13.3 mi S B. de los Angeles, 1–13 Mar. 1988, N. Broomfield, 4 ♀ (SDNH); 14.4 mi S Campo Alfonsina, 20–26 Oct. 1987, N. Broomfield, 20 ♂, 31 ♀ (SDNH); 19 mi SW Campo Alfonsina (Canyon), 27–28 Oct. 1987, N. Broomfield, 1 ♂, 1 ♀ (SDNH); 2.8 mi S Catavina, 23 Mar. 1981, Faulkner & Brown, 2 ♂, 4 ♀ (SDNH); 25.5 mi NE El Arco, 11–15 Dec. 1987, N. Broomfield, 1 ♂, 1 ♀ (SDNH); 3 mi S B. de los Angeles, 2 Nov. 1987, N. Broomfield, 1 ♀ (SDNH); 51 mi S Catavina, 7 Apr. 1982, Faulkner & Brown, 1 ♀ (SDNH); 7 mi S Chapala, 29 Oct.–1 Nov. 1987, N. Broomfield, 2 ♂, 7 ♀ (SDNH); 9 mi E El Bonfil, 11 June 1986, Broomfield, 1 ♂ (SDNH); 9 mi S Rosarito, 5 Oct. 1983, Faulkner & Andrews, 1 ♀ (SDNH); Bahia de Los Angeles, 30 Mar. 1983, C. Brey, 1 ♂ (SDNH); El Marmol, 15 Mar. 1947, 1 ♀, Harbison, 12 Apr. 1940, 2 ♂ (SDNH); Sierra San Pedro Martir, Las Encinas, 15 June 1980, Brown & Faulkner, 1 ♀ (SDNH); Wash, 2 mi N Catavina just east of Hwy 1, 3 Apr. 1992, J. Brown, 1 ♂, 1 ♀ (SDNH). BAJA CALIFORNIA SUR: 16.3 mi NE Arco, 8–10 Mar. 1988, N. Bloomfield, 1 ♂, ♂ genitalia slide USNM 46365; 2 mi NW El Triunfo, 12 Aug. 1966, J.A. Chemsak (UCB); 2 mi SE San Bartolo, 900, 9 Nov. 1993, Y.F. Hsu (UCB); 26 mi W. La Paz, 11 Aug. 1966, J.A. Chemsak, 1 ♀ (UCB); 7 mi S San Pedro, 10 Aug. 1966, J. Powell (UCB); 7 mi SE Guerrero Negro, 8 Apr. 1976, J. Doyen & P. Rude, 2 ♂, 10 ♀ (UCB); 90 km NW La Paz, 8 Nov. 1993, Y.F. Hsu, 1 ♂, 2 ♀ (UCB); El Coyote, 12 Apr. 1972, R.W. Holland, 1 ♂ (AMNH); Sierra Laguna, 17 air mi ENE Todos Santos, 6000', 12–18 Dec. 1979, 3 ♂, J. Doyen & W. Tschinkel, 6 ♂, 1 ♀, P. Rude (UCB); 16.3 mi NE El Arco, 8–10 Mar. 1988, N. Broomfield, 2 ♂, 3 ♀ (SDNH); 2 mi W Catavina, 4 Apr. 1935, C.F. Harbison, 3 ♂, 4 ♀ (SDNH); 3 mi NE San Isidro (La Purisima), 14 Apr. 1985, Broomfield & Faulkner, 2 ♀ (SDNH); 3.3 mi S El Cien, 26 Sep. 1981, D. Faulkner & F. Andrews, 1 ♂, 2 ♀ (SDNH); 5 mi N San Isidro, 18 July 1986, Broomfield, 1 ♀ (SDNH); 7 mi SW Loreto, 12 Oct. 1981, D. Faulkner & F. Andrews, 1 ♀ (SDNH); 9.2 mi SSE Mulege, 23 Sep. 1981, F. Andrews & D. Faulkner, 1 ♀ (SDNH); I. San Jose, NW end, 11 July 1985, D.K. Faulkner, 1 ♂ (SDNH); La Paz, Econohotel Palmira, 29 Nov. 1980, Brown & Brown, 1 ♂ (SDNH); San Isidro, 29 May 1984, Broomfield & Faulkner, 8 ♂, 3 ♀ (SDNH). CHIAPAS: 8 mi NW San Cristobal, 28 May 1969, A. Mutuura, 1 ♂ (CNC). COAHUILA: 10 mi N Monclova, 1500, 7 July 1963, Duckworth & Davis, 5 ♂, 1 ♀, ♂ genitalia slide USNM 46330; Saltillo, 7 Aug. 1963, P.J. Spangler, 1 ♀; Saltillo, 23 May 1952, ♂ genitalia slide on 8699, ♀ genitalia slide on 8756, M. Casier, W. Gertsch, R. Schrammei, 1 ♂, 1 ♀ (AMNH); 25 mi S Cd. Acuna, 30 June 1983, Wolfe & Valverde, 1 ♂, 3



♀ (SDNH). GUANAJUATO: San Miguel de Allende, 14 May 1979, J.R. Powers, 2 ♀ (UCB). MORELOS: Jalastoc, 4 Feb. 1949, J.J. McKelvey, 1 ♀. NUEVA LEON: 2 mi S Monterrey, Chipinque Mesa, 4200, 10 Aug. 1963, Duckworth & Davis, 1 ♀; 3 mi E Galeana, 5000, 7–9 Aug. 1963, Duckworth & Davis, 3 ♂, 2 ♀; Laredo, Km 1086, 375m, 29 Nov. 1950, C. Dowling, 1 ♂; Monterrey, 8 Aug. 1963, P.J. Spangler, 4 ♂, 9 ♀, ♂ genitalia slide USNM 46331, 46332; Monterrey, 21 Mar. 1999, B. Mather, 1 ♀ (BM); 2 mi S. Monterrey, Chipinque Mesa, 4200, 10 Aug. 1963, Duckworth & Davis, 1 ♀ (CNC); 5 mi S. Monterrey, 10 July 1963, 1 ♂, 11 July 1963, 1 ♂, 7 July 1963, 1 ♀, 13 July 1963, 1 ♀, 27 July 1963, 3 ♀, ♀ genitalia slides MGP # 1124, 1125, H. & A. Howden (CNC); Chipinque Mesa, nr. Monterrey, 5400, 22 July 1963, 1 ♀, ♀ genitalia slide MGP # 1126, H. & A. Howden (CNC); Linares, 13 Apr. 1954, D.H. Janzen, 1 ♂ (UCB); Monterrey, 9 May 1976, J.R. Powers, 5 ♂, 2 ♀ (UCB). PUEBLA: 2 mi SW Tehuacán, 5300, 4 Oct. 1975, 3 ♂, 1 ♀, 5 Oct. 1975, 1 ♂, 2 ♀, J.A. Powell (UCB); 7.5 km NE Azumbilla, 2200m, 21 Aug. 1987, Brown & Powell, 1 ♀ (UCB). QUERETARO: Km 4 Carretera La Lagunita-Tilaco, 1160 m, 11 Jan. 1998, Vences & Ibarra, 1 ♀ (UNAM). SAN LUIS POTOSI: 15 mi N Valles, 18 May 1952, ♀ genitalia slide on 8758 M. Casier, W. Gertsch, R. Schrammei, 1 ♀ (AMNH); Tamazunchale, 20 May 1952, ♂ genitalia slide on 8713 M. Casier, W. Gertsch, R. Schrammei, 1 ♂ (AMNH); Xilitla, Vencidor Station, 22 Apr. 1977, W.H. Howe, 2 ♂ (AMNH). SONORA: 22 mi N Cd. Obregon, 11 June 1962, D.H. Janzen, 1 ♀ (UCB); 5 mi S Presa Obregon, 23 Mar. 1980, J.T. Doyen, 1 ♀ (UCB); Rio Yaqui, 12 mi E Esperanza, 300, 25 Mar. 1980, J. Doyen (UCB); 20 mi S Sonoyta, 22 Sep. 1967, C.F. Harbison, 1 ♀ (SDNH); 4.3 mi E Moctezuma, 2–4 Sep. 1987, N. Broomfield, 2 ♀ (SDNH). TAMAULIPAS: Guemez, 28 June 1965, P.J. Spangler, 1 ♀; 4 mi SW C. Victoria, 10 July 1963, Duckworth & Davis, 1 ♀ (CNC); Gomes Farias, 3 Oct. 1986, L. Cervantes, 1 ♀ (UNAM); Victoria, 12 Mar. 1953, 1 ♀, 14 Mar. 1953, 14 Mar. 1953, 1 ♂, 1 ♀, D.H. Janzen (UCB). VERACRUZ: 36 mi S Tantoyuca, 120m, 3 July 1983, K. Wolfe & N. Valverde, 3 ♀ (SDNH). U.S.A.: ARIZONA: Pima Co.: Baboquivra Mts., 5000 ft., 15–30 June 1923, 1 ♂, 1 ♀, ♂ genitalia slide made VI-3-35 A.G. Richards, 1–7 July 1923, 1 ♀, O.C. Poling. CALIFORNIA: Imperial Co.: Carrizo, 10 Mar. 1928, C.C. Searl, 1 ♂ (SDNH). Orange Co.: Silverado Canyon, Santa Ana Mts., 1650, 25 Apr. 1979, G.A. Marsh, 1 ♂ (UCB). Riverside Co.: Palm Springs, 16–23 Apr., 1 ♂, 3 ♀, ♀ genitalia slide USNM 40520, 29 Mar. 1952, 1 ♀, 19 May 1950, 1 ♀, A.H. Rindge (AMNH); Boyd Desert Research Center, 4 mi S Palm Desert, 6 Apr. 1963, J. Powell, 1 ♂ (UCB); Chino Canyon, Palm Springs, 19 Apr. 1950, E.C. Johnston, 1 ♂ (CNC); Chino Cyn, nr. Palm Springs, 20 Apr. 1960, J. Powell, 5 ♂, 3 ♀ (UCB). San Bernardino Co.: Joshua Tree Nat. Mon., Indian Cove, 25–26 Mar. 1981, S.E. Miller & P.M. Mercer, 3 ♂; Loma Linda, 8–15 Apr., 2 ♂, 4 ♀, ♂ genitalia slide USNM 446384, ♀ genitalia made VI-11-35 A.G. Richards, 16–23 Apr., 3 ♂, 2 ♀, ♀ genitalia slide USNM 46783, 16–23 May, 2 ♂, 1–7 July, 1 ♀; San Bernardino, 27 May 1920, E. Piazza, 1 ♂; 29 Palms, 20 Apr. 1950, E.C. Johnston 1 ♂ (CNC); Afton Rd., 23 mi SW Baker, 23 Apr. 1977, Cave & Chemsak, 1 ♀ (UCB). San Diego Co.: Jacumba, 1, 28 May 1924, 2 ♂, 20, 24 June 1924, 3 ♂, 3 ♀, ♀ genitalia slide USNM 46325, H.G. Dyar, 9 May 1924, 1 ♂ (CNC); Oriflamme Cyn., Anza Borego State Park, 18 Apr. 1998, N. Broomfield, 9 ♂, 4 ♀, ♂ genitalia slide USNM 46323; San Diego, 24 May 1924, 1 ♂, 23 July 1924, 1 ♀, H.G. Dyar, 29 May 1920, 1 ♀, 30 June 1920, 1 ♂, 17 June 1920, 1 ♂, E. Piazza, Apr. 1 ♀, ♀ genitalia slide made VI-12-35 A.G. Richards, Apr., 1 ♂, ♂ genitalia made VI-2-35, Coquillet; Borego, 1 May 1941, 1 ♂, G.H. & J.L. Sperry, Apr. 1941, 1 ♀, June 1946 1 ♀, N. Crickner (AMNH); La Jolla, 25 June 1963, J. Powell, 1 ♀ (UCB); 1 mi W Jacumba, 25 May 1981, C. Bruyey, 1 ♀ (SDNH); 2 mi E Jacumba, 17 Aug. 1979, Brown & Faulkner, 1 ♂ (SDNH); 5 mi N Escondito, 250 m, 24 Apr. 1983, 1 ♀, 16 June 1983, 1 ♀, K. Wolfe & M. Valverde (SDNH); Boulevard-Manzanita, 3 June 1980, R. Messner, 1 ♂

(SDNH); Crouch Meadow Spr., 22 May 1979, D.K. Faulkner, 1 ♀ (SDNH); Green Vly. TT Poway, 5 Apr. 1981, C. Bruyey, 1 ♂ (SDNH); Jacumba, 20 June 1978, Faulkner & Brown, 1 ♂ (SDNH); Kitchen Creek Cyn., 25 May 1981, C. Bruyey, 1 ♂ (SDNH); NAS Miramar, Lep. Sur. Site 7, 3.5 mi E I-15, 0.25 mi S Green Farms Road, 22 Apr. 1996, N. Broomfield, 1 ♀ (SDNH); Rancho Bernardo Industrial Park, 30 Apr. 1981, C. Bruyey, 1 ♀ (SDNH); San Diego Wild Animal Park, San Pasqual, 19 June 1982, G.P. Bruyey, 1 ♂ (SDNH). Stanislaus Co.: Del Rio, 26 Apr. 1959, M.R. MacKay, 2 ♂ (CNC). La Puerta Valley, July 1911, G.H. Field, 2 ♂, 1 ♀ (SDNH); Vallecito Vy., 4–29, C.F. Harbison, 1 ♀ (SDNH). TEXAS: Bexar Co.: San Antonio, 24–30 Mar., 2 ♂, 2 ♀, ♂ genitalia slide USNM 46324, 1–7 Apr., 1 ♂, 1 ♀, H. Schwarz. Brewster Co.: K-Bar Ranch, Chisos Mountains, 3400, 5 June 1973, D.C. Ferguson, 1 ♂; Alpine, 22 May 1950, E.C. Johnston 1 ♀ (CNC). Cameron Co.: San Benito, 24–30 Apr., 1 ♂, 8–15 May, 1 ♂, 1 ♀, ♀ genitalia slide USNM 46393, 16–23 May, 4 ♀. Culberson Co.: Sierra Diablo, 20 mi NNW Van Horn, 29 May 1973, D.C. Ferguson, 1 ♂. Goliad Co.: Goliad, Nov. 1895, 1 ♀, ♀ genitalia slide USNM 46392. Kerr Co.: Kerrville, 31 May 1906, 2 ♂, ♂ genitalia slide USNM 46394, F.C. Pratt. La Salle Co.: Artesia Wells, 11 July 1972, A. & M.E. Blanchard, 1 ♀; Cotulla, 12 May 1907, Crawford & Pratt, 2 ♂. Nueces Co.: Corpus Christi, 1 ♀; N. Padre Island, 9 Sep. 1974, A. & M.E. Blanchard, 2 ♂. San Patricio Co.: Sinton Welder Wildlife Foundation (San Patricio), 22, 24–26 May 1962, 9 ♂, 8 ♀, 5 ♂ and 2 ♀ genitalia slides USNM 46385–46390, 46395, A. & M.E. Blanchard. Uvalde Co.: Garner State Park, 21 Sep. 1965, 1 ♀, ♀ genitalia slide USNM 46391, A. & M.E. Blanchard. Victoria Co.: Victoria, 30 Mar., 1 ♀, 4 Apr. 1 ♀, E.A. Schwarz. Williamson Co.: Georgetown, 21 Apr. 1937, L.J. Milne, 1 ♂ (CNC). No specific locality, 1 ♂, 2 ♀.

**Larval host.** Unknown.

**Distribution** (Fig. 60). Collections indicate a disjunct distribution for *B. similaris*. The western distribution is from southern California throughout Baja California, Mexico, with an isolated record from the Baboquivari Mountains in south central Arizona and a few scattered localities in northwestern Sonora, Mexico. The eastern distribution extends from central Texas along eastern Mexico to central Chiapas.

**Discussion.** The females of *B. similaris* show four distinct phenotypes. There are two maculate forms, a light one (Fig. 21), and a dark one (Fig. 22) that are very similar to the males (Figs. 19–20). There is an immaculate form that lacks most of the pattern and has a large dark reniform spot (Fig. 23). A fourth form is intermediate in maculation with a distinct median band and median line with the terminal half of the forewing a cinnamon ground color (Fig. 24). Richards (1939) described the race *californica* for a pale form of *B. similaris* from southern California and northern Baja California. In this form the overall coloration is lighter and the median band and reniform spot are pure white. The hindwing is pure white in the *californica* race, but is generally darker in the Texas and Mexican specimens.

### *Bulia deducta* (Morrison)

(Figs. 7–8, 25–30, 38, 43, 48, 53, 58, 61)

*Syneda deducta* Morrison 1875:220.

*Syneda pavitensis* Morrison 1875:221. [Synonymized by Richards 1936:434.]



*Cirrhobolina incandescens* Grote 1875:117. [Synonymized by Richards 1936:434.]

*Cirrhobolina mexicana* var. *vulpina* H. Edwards 1882:14. [Synonymized by Richards 1936a:435.]

*Syneda mexicana* var. *albina* Strecker 1900:35. [Synonymized by Richards 1936a:435.]

*Bulia deducta*, Richards 1936a:434; Richards 1941:263; Poole 1989:180; Poole and Gentili 1996:729.

**Diagnosis.** *Bulia deducta* is most likely to be confused with *B. similaris*. The only way to accurately identify these species is by examining the characters of the male and female genitalia. In the male, *B. deducta* can be separated from *B. similaris* by the shape of the juxta. The dorsal margin of the juxta is V-shaped in *B. deducta* (Fig. 43) and U-shaped in *B. similaris* (Fig. 42). At the apex of the aedeagus the patch of spiculations near the apex are smaller and cover a larger area in *B. deducta* (Fig. 48), and these spiculations are larger and cover a smaller area in *B. similaris* (Fig. 47). The cornuti on the disto-lateral diverticulum in *B. deducta* are larger and fewer in number (Fig. 53), and in *B. similaris* they are smaller and greater in number (Fig. 52). The females can be separated by the shape of the median prong of the seventh abdominal segment. In *B. deducta* the median prong is greater than the height of the lateral projections (Fig. 58), and in *B. similaris* the length of the median prong is less than or equal to the height of the lateral projections (Fig. 57).

**Description. Adult male. Forewing:** Length 13.0–17.0 mm. **Genitalia** (Figs. 38, 43, 48): Saccus with costal lobe large, apex truncate; apex an elongate projection. Juxta with V-shaped dorsal margin. Aedeagus without dorsal spiculations near apex. Vesica with largest spine on disto-lateral diverticulum, smaller spine on lateral diverticulum; minute cornuti on apex of disto-lateral diverticulum and on ventral diverticula; patch of large cornuti medially on disto-lateral diverticulum.

**Adult female. Forewing:** Length 12.5–18.5 mm. **Genitalia** (Figs. 53, 58): Seventh segment deeply invaginated; median prong width less than or equal to height, extending above lateral projections, apex truncate. Corpus bursa with a band of elongate spicules below junction with ductus bursae.

**Type material.** *Syneda deducta* Morrison; holotype ♂, U.S.A., Texas, Waco, in the Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts. *Syneda pavitensis* Morrison; holotype ♀, U.S.A., Texas; Peab. Acad.; *Syneda pavitensis* Type Morr. [Hand written in black ink], in USNM. *Cirrhobolina incandescens* Grote; holotype ♀, U.S.A., Texas, in BMNH. *Cirrhobolina mexicana* var. *vulpina* H. Edwards; holotype ♀, U.S.A., [no locality label]; *Cirrhobolina mexicana* Behr var. *vulpina* Hy. Ed.; Col. B. Neumogen; Collection Brklyn Mus; Type No. 34118 U.S.N.M. [Red label black type]; Genitalia Slide USNM 40256 [green label], ♀ gen. 978, 24 May 34 FHB [hand written black ink]; in USNM. *Syneda mexicana* var. *albina* Strecker; 2 syntypes ♀, Mexico, Chihuahua, in Field Museum of Natural History, Chicago, Illinois.

**Material examined.** 839 ♂ and 863 ♀. All material is from the USNM unless otherwise noted. **CANADA:** MANITOBA:

Cartwright, 1 ♂. **MEXICO:** BAJA CALIFORNIA [label data]: 9 mi SE Catavina, 16 Oct. 1967, G.A. Marsh, 1 ♂ (UCB); Gaskill's, 14 Nov. 1936, C.F. Harbison, 1 ♂ (SDNH). BAJA CALIFORNIA NORTE: Laguna Salada, 21 Sep. 1967, G.A. Marsh, 1 ♂ (UCB); 14.4 mi S Campo Alfonsina, 20–26 Oct. 1987, N. Broomfield, 1 ♀ (SDNH); 8 mi E Tecate, 6 July 1984, Brown and Tocco, 1 ♀ (SDNH); Cantil, Tajo Canyon, 25 Oct. 1955, Harbison, 3 ♂, 5 ♀ (SDNH); Tajo Canyon, 25 Oct. 1955, Harbison, 3 ♂, 4 ♀ (SDNH). CHIAPAS: 20 mi NE Huixtla, 900 m, 9 July 1983, Wolfe & Valverde, 1 ♀ (SDNH). CHIHUAHUA: 12 mi N Escalon, 18 Apr. 1961, Howden & Martin, 1 ♂, 3 ♀ (CNC); 25 mi W Del Perral, 6800, 14 July 1964, J.A. Chemsak, 1 ♂ (UCB); 42 mi N Chihuahua in cyn. 3 mi W Parrita, 2 June 1981, J. Doyen, 1 ♂, 2 ♀ (UCB); Majalca Rd., 25 mi NW Chihuahua, 14–17 Apr. 1961, Howden & Martin, 2 ♂ (CNC); Mesa del Huracán, 7400, 21–25 July 1964, J.E.H. Martin, 2 ♀ (CNC). COAHUILA: sand dunes at Bilbao, 8 mi N Viesca, 30–31 May 1981, J. Doyen, J. Liebherr, 1 ♀ (UCB); 25 mi S Cd. Acuna, 300 m, 30 June 1983, Wolfe & Valverde, 1 ♂, 3 ♀ (SDNH). DURANGO: Lerdo, 1 ♀; 10 mi W El Salto, 26 June 1964, 1 ♂, 12 July 1964, 1 ♀, W.C. McGuffin, 26 June 1964, 1 ♂, 5 July 1964, 1 ♂, 8 July 1964, 1 ♀, J.E.H. Martin (CNC); 16 mi SE Durango, 14 July 1964, W.C. McGuffin, 2 ♀ (CNC); 5 mi W Durango, 11 June 1964, J.E.H. Martin, 1 ♂ (CNC); Durango, 3 May 1961, Howden & Martin, 1 ♀ (CNC); Vte. Gro., 3 June 1984, 1 ♀ (UNAM). NUEVA LEON: Monterrey, 25 Nov. 1909, F.C. Bishopp, 1 ♂, ♂ genitalia made V-12-40 A.G. Richards; Gomez Palacio, 11 May 1918, U.C. Loftin, 1 ♂; Chipinque Mesa, nr. Monterrey, 5400', 22 July 1963, 1 ♀, H. & A. Howden, 1760', 27–28 Apr. 1969, J.E.H. Martin, 2 ♀ (CNC); Linares, 9 May 1969, 7 ♂, ♂ genitalia slides MGP # 1129, 1130, 2 ♀ (CNC). SONORA: Nogales, 2 Aug. 1919, F.J. Dyar, 1 ♂; 95 mi E San Luis R.C., Hwy. 2, 4 Apr. 1966, M. Lundgren, 1 ♂ (UCB); Alamos, 1 July 1971, G. Kageyama, 1 ♂ (UCB); 4.3 mi E Moctezuma, 18–21 July 1987, 1 ♀, 2–4 Sep. 1987, 3 ♂, 3 ♀, N. Broomfield (SDNH). CUYAMACA, 20 June 1940, 1 ♀ (SDNH). **U.S.A.:** ARIZONA: Apache Co.: White Mts., near McNarry P.O., 1–5 Aug. 1925, 1 ♂, 1 ♀, O.C. Poling, ♂ genitalia made VI-8-35, A.G. Richards. Cochise Co.: Ash Canyon Rd., (1/2 mi W Hwy 92, Lot 4, 5100 ft. el.), 19 May 1981, 1 ♀, June 1982, 2 ♀, 18 June 1980, 1 ♀, 13, 25 July 1980, 1 ♂, 1 ♀, N. McFarland; Cherry Canyon, near Cherry, 9 May 1959, R.F. Sternitzky, 1 ♀; Chiricahua Mts., 3 ♂, 1 ♀, 26 June, H.G. Hubbard, 1 ♂, 2 ♀; Guadalupe Canyon, Peloncillo Mts., 4250, 19 June 1976, 5 ♂, 2 ♀, C.J. & S. Werner; Hereford, 2 ♂, 1 ♀, C.R. Biederman; Huachuca Mts., 9 ♂, 11 ♀, ♂ genitalia made VI-5-35 A.G. Richards; Palmerlee, 17 ♂, 24 ♀, 2 ♂ genitalia made VI-1-35, VI-5-35, A.G. Richards, 1–7 July, 1 ♀, 8–14 July, 1 ♂, Aug. 1 ♂, 1 ♀; Paradise, 15 ♂, 19 ♀, June 43 ♂, 19 ♀, 3 ♂ genitalia made VI-5-35, 8-VI-1935 + H58 A.G. Richards, July 5 ♂, 5 ♀, Aug. 7 ♂, 9 ♀, Sep. 1 ♂; Southwest Research Station, Chiricahua Mts., 16 June 1963, 4 ♂, 1 ♀; SW Res. Sta., Chiricahua Mts., 5400', 5–8 July 1964, D.R. Davis, 1 ♂, 1 ♀; SW Research Sta., Chiricahua Mts., 5 mi W Portal, 22 June 1956, O.L. Cartwright, 1 ♂, 2 ♀; Wilgus, 3 ♂, 1 ♀; Ash Canyon, Huachuca Mts., 19 Oct. 1966, 1 ♂, 22 Oct. 1966, 2 ♂, R.F. Sternitzky (CNC); Barfoot Park, Chiricahua Mts., 3 May 1934, G.H. & J.L. Sperry, 1 ♀ (AMNH); Carr Canyon, Huachuca Mts., 28 Sep. 1967, R.F. Sternitzky, 1 ♀ (CNC); Chiricahua Mts., Onion Saddle, 29 July 1996, Opler & Buckner, 1 ♀ (CSU); Cochise Stronghold, 3–5 Sep. 1965, J.T. Doyen, 1 ♂, 1 ♀ (UCB); Coronado Nat. For., Harshaw Cr., 7 mi SE Patagonia, 5 Aug. 1996, P. Opler, 1 ♂ (CSU); Coronado Nat. For., Upper Pinery Cyn., campground, Chiricahua Mts., 30–31 July 1996, P. Opler & E. Buckner, 1 ♂ (CSU); Garden Canyon, Huachuca Mts., 26 July 1966, R.F. Sternitzky, 1 ♂ (CNC); Guadalupe Cyn., 29 mi E Douglas, 15–16 Aug. 1972, J.T. Doyen, 1 ♂ (UCB); Huachuca Mts., 30 May 1910, 1 ♂, 1 June 1910, 2 ♀, 5 June 1910, 1 ♂, L.R. Clemence (CNC); Huachuca



- Mts., Ash Canyon Rd., 6 Aug. 1996, P.A. Opler, 1 ♀ (CSU); Miller Canyon, Huachuca Mts., 23 Aug 1966, R.F. Sternitzky, 1 ♂ (CNC); Parker Canyon, Huachuca Mts., 6 Sep. 1966, 1 ♂, 1 ♀, 16 Sep. 1966, 1 ♂, R.F. Sternitzky (CNC); Perilla Mts., 8 mi E Douglas, 29 Apr. 1989, 1 ♂ (UCB); Pinery Cyn., Chiracahua Mts., 6500', 6–7 Aug. 1991, D. Rubinoff, Y.R. Hsu, J.A. Powell, 1 ♀ (UCB); Ramsey Canyon, 15 mi S Sierra Vista, Huachuca Mts., 6000', 5 Aug. 1967, 1 ♂, 9 Aug. 1967, 1 ♀, 15 Aug. 1967, 1 ♂, 1 ♀, Sternitzky (CNC); Ramsey Canyon, Huachuca Mts., 11 May 1966 1 ♀, 7 June 1965, 1 ♀, 8 Sep. 1967, 1 ♂, 1 ♀, R.F. Sternitzky (CNC); Rustler Park, Chiracahua Mts., 8500', 3 July 1972, 1 ♀, 14 July 1972, 1 ♂, J. Powell, 2 Aug. 1973, 1 ♀, J. Powell & S. Szerlip (UCB); Sierra Vista, 2 May 1966, 2 ♀, 8 July 1967, 1 ♀, 23 July 1967, 1 ♀, 17 Aug. 1967 1 ♀, 5 Sep. 1966, 1 ♀, R.F. Sternitzky (CNC); Southwestern Research Station, Chiricahua Mts., 10 July 1962, C.W. Kirkwood, 1 ♂, 1 ♀ (CNC); Sunnyside, 7 Sep. 1966, R.F. Sternitzky, 2 ♀ (CNC); SW Research Sta. of AMNH, Cave Creek Canyon, Chiracahua Mts., 5400 ft., 16 June 1958, 1 ♀, J.M. & S.N. Burns, 28 June 1960, 2 ♂, 1 ♀; J.M. Linsley (UCB); SW Research Sta., 5 mi W Portal, 22 July 1959, 1 ♂, 4 Aug. 1959, 1 ♂, E.G. Linsley, 24 July 1961, 1 ♀, J.M. Linsley (UCB); SW Research Sta., Chiracahua Mts., 9 Sep. 1958, E.G. Linsley, 2 ♂ (UCB); Turkey Creek, Chiracahua Mts., 5600', 1–2 Aug. 1986, J. Brown, 3 ♂, 1 ♀ (UCB); 4.5 mi SW Portal, 16–26 June 1981, 1 ♂, 1 ♀, 25–31 July, 1981, 1 ♀, 1–3 Sep. 1981, 1 ♂, 1 ♀, K. & M. Cazier (SDNH); Chiricahua Mts., 3 July 1908, V.L. Clemence, 1 ♂ (SDNH); Chiricahua Mts., Portal, 17–19 Aug. 1979, D.K. Faulkner, 5 ♂, 8 ♀ (SDNH); Douglas, Oct. 1961, 1 ♀ (SDNH); Dragoon Mts., Cochise Stronghold, 8 Aug. 1980, 1 ♀ (SDNH); Huachuca Mts., Ash Canyon Rd. (1/2 mi W Hwy 92, Lot 4, 1100 ft.), 5 Apr. 1979, 1 ♀, 23, 27, 28 May 1981, 2 ♂, 4 ♀, 13 June 1979, 1 ♀, 25, June 1979, 1 ♂, 30 June 1979, 1 ♀, 4, 8, 11, 14 July 1979, 4 ♀, 13 July 1980, 1 ♀, 16 July 1981, 1 ♂, 14, 16, Aug. 1979, 3 ♂ 25, 27, Aug. 1979, 2 ♂, 26 Aug. 1979, 1 ♀, 27 Aug. 1981, 1 ♀, 1 Sep. 1981, 1 ♀, 10 Sep. 1980, 1 ♂, 6 Oct. 1980, 1 ♂, 13 Oct. 1979, 1 ♂, 24 Oct. 1979 1 ♂, N. McFarland (SDNH); Rustler Park, Chiricahua Mts., 27, 29 June 1931, 2 ♀ (SDNH). Gila Co.: Christmas, 1 ♂, 1 ♀; 1902, O.C. Poling, 1 ♀; 15–30 June, O.C. Poling, 1 ♀. Graham Co.: Safford, 8 Aug. 1964, J. Powell, 4 ♀ (UCB). Hempstead Co.: Hope, 22 July 1931, L. Knobel, 1 ♂, ♂ genitalia slide I-5-32 A.G. Richards. La Paz Co.: Ehrenberg, 10 Aug. 1938, F.H. Parker, 1 ♀. Maricopa Co.: Phoenix, 2 ♀, Apr. 24–30, 1 ♀, 14 June, 1 ♀, J. Doll, 22 June, 1 ♀, Collection Brklyn. Mus., 6, 12 Apr. 1978, 2 ♀, 21, 23, 28, May 1978, 4 ♀, 10 Aug. 1974, 1 ♂, R. Wielgus; Rio Verde Mts., Phoenix, 9 1983, W. Barnes, 1 ♂, 2 ♀; Tempe, 5 Apr. 1920, E.V. Walter & H.L. Arnold, 1 ♀; 24–30 July, 1 ♂; Scottsdale, Mt. Shadows, 20–22 June 1978, M. Buegler, 1 ♂ (UCB). Mohave Co.: Hualapai Mts., 24–31 May, 1 ♀; Pierce Ferry, 5–7 May 1967, D. Davis, 1 ♂. Pima Co.: Baboquivara Mts., Aug. 3 ♂, 1 ♀; Baboquivara Mts., 5000 ft., 1–15 June 1923, 9 ♂, 8 ♀, 1–15 June 1924, 21 ♂, 17 ♀, 15–30 June 1923, 110 ♂, 58 ♀, 8 ♂ genitalia slide made VI-3-35 A.G. Richards, 1–7 July 1923, 20 ♂, 16 ♀, 1–15 July 1923, 2 ♂, 3 ♀, 1–15 July 1924, 15 ♂, 5 ♀, 15–20 July 1923, 1 ♀, 15–30 July 1923, 1 ♂, 15–30 July 1924, 1 ♂, 1–15 Aug. 1924, 2 ♂, 1 ♀, 15–30 Aug. 1923, 1 ♂, 2 ♀, 15–30 Aug. 1924, 1 ♀, 1–15 Sept. 1923, 3 ♀, 1–15 Sept. 1924, 1 ♂, 4 ♀, 15–30 Oct. 1923, 1 ♂, 1 ♀, O.C. Poling; Redington, 16 ♂, 18 ♀, 2 ♂ genitalia slides made VI-1-35 and VI-8-35 A.G. Richards; Santa Catalina Mts., 1 ♀, 1–7 Aug., 3 ♀; Santa Rita Mts., 1 Apr. 1940, 1 ♀, Aug. 1960, 1 ♂, 1 Sep. 1960, 1 ♂, 2 ♀, K. Brown, 14, 15 June 1898, 1 ♂, 2 ♀, E.A. Schwarz, July 1 ♀, Coll. Brklyn. Mus., 26 July 1925, 1 ♂; Selis P.O., Indian Oasis, 1–10 May 1923, O.C. Poling, 1 ♂, ♂ genitalia slide made VI-5-35 A.G. Richards; Tucson, May 22, 1 ♂, June 14, 1 ♂, 1 ♀, J. Doll, 1 ♀, B. Neumoegen; 3 mi N Ajo, 19 Feb. 1963, W.C. Cook, 1 ♂ (CNC); Alamo Canyon, Ajo Mts., 22 Apr. 1947, G.H. & J.L. Sperry, 1 ♂ (AMNH); Baboquivari Mts., 26 Apr. 1938, 28 Apr. 1938, 2 ♀, G.H. & J.L. Sperry (AMNH); Baboquivari Mts., 5000 ft., 15–30 June 1923, O.C. Poling, 1 ♂, 25 Apr. 1947, G.H. & J.L. Sperry, 1 ♀ (CNC); Blacksprings Campground, Madera Canyon, 10 July 1976, D. Whitman, 1 ♂ (UCB); Madera Canyon, 5–12 Sep. 1951, W. Hammer, 1 ♂ (CNC); Madera Canyon, Santa Rita Mts., 27 Aug. 1962, 1 ♀, H.E. Milliron, 18 Sep. 1966, 1 ♀, 22 Sep. 1966, 1 ♂, C.W. Kirkwood (CNC); Madera Canyon, Santa Rita Mts., 6 June 1968, 2 ♂, 1 ♀, R. Opler & J. Powell, 2 ♀, P. Opler, 3–5 Sep. 1969, 1 ♂, J. Powell (UCB); Molino Basin, Santa Catalina Mts., 4500 ft., 12 June 1968, J.M. & S.N. Burns, 1 ♂ (UCB); Organ Pipe Nat. Mon., 24 Mar. 1964, 1 ♂, C.W. O'Brien, 1 ♂, C.N. Slobodchikoff (UCB); Tucson, 5 June 1935, 1 ♀, 10 June 1935 1 ♀, Bryant, 30 June 1935, O. Watts, 1 ♂ (CNC), 5 Mar. 1987, J. Reichel, 1 ♂ (AMNH); Bates Well, 18 Nov. 1939, 1 ♀ (SDNH); Madera Canyon, Santa Rita Mts., 4 Aug. 1980, 1 ♀, 5 Aug. 1980, 1 ♀, C. Bruyey (SDNH); Santa Rita Mts., 14 Sep. 1977, M. Plagens, 1 ♀ (SDNH). Pinal Co.: Superior, 5 June 1938, 1 ♂, ♂ genitalia USNM 46370, 15 June 1938, 1 ♀, S.E. Crumb; Oracle Junction, 3300, 9 May 1964, 1 ♀, 12 May 1964, 1 ♀, W.C. Cook (CNC); Rancho Linda Vista, nr. Oracle, 4 May 1967, R.F. Sternitzky, 1 ♂, 1 ♀ (CNC). Santa Cruz Co.: Madera Canyon, Santa Rita Mts., 5100', 10–26 July 1964, 2 ♀, D.R. Davis, 5 Sep. 1956, 6 ♂, 3 ♀; 12 mi S Sonoita, Hidden Springs Canyon, 29 July 1966, R.F. Sternitzky, 1 ♂, 1 ♀ (CNC); 5 mi SE Sonoita, 30 July 1966, R.F. Sternitzky, 1 ♂ (CNC); Canelo, 22 Apr. 1966 1 ♀, 5 Sep. 1966, 1 ♂, 1 ♀, 12 Sep. 1966, 2 ♂, R.F. Sternitzky (CNC); Elgin, 14 Aug. 1966, 1 ♀, 4 Sep. 1966, 1 ♀, R.F. Sternitzky (CNC); Madera Canyon, Rec. Area, Santa Rita, 30 July 1991, P.A. Opler, 1 ♂ (CSU); Nogales, 12 July 1906, 1 ♂, 12 Aug. 1906, 1 ♀, 14 Aug. 1906, 1 ♀, 24 Aug. 1906, 1 ♂, 21 Sep. 1906, 1 ♂, 1 ♀, A. Koebele (CNC); Patagonia, 30 Apr. 1910, 1 ♀, L.R. Clemence (CNC); Patagonia Mts., 7 mi SE Nogales, 1 Aug. 1991, P. Opler, Y.F. Hsu, D. Rubinoff, 1 ♀ (UCB); Sycamore Cyn., Hank Yank Springs, 9 mi W Pena Blanca, 31 July 1991, P.A. Opler, 1 ♀ (CSU); Madera Canyon, 5 Aug. 1980, 1 ♂, 15 Aug. 1980, 1 ♀, 22 Aug. 1978, 3 ♀, D.K. Faulkner (SDNH); Nogales, 9 Aug. 1977, D.K. Faulkner, 1 ♂, 1 ♀ (SDNH). Wasington Co.: 20 July 1966, R.L. Brown, 1 ♀ (CNC); Yavapai Co.: Congress Junction, 23 June 1938, 1 ♂, ♂ genitalia USNM 46371, S.E. Crumb; Dewey, 16–23 June, 1 ♀; Douglas, 16–23 May, 4 ♀, 8–15 June 3 ♀, 16–23 June 1 ♂, 1 ♀, 8–15 Aug., 1 ♀; Prescott, 16–23 June, 1 ♂, Barnes Collection, July 14, 1 ♀, J. Doll; 4 mi N Prescott, 22 May 1973, 1 ♂, 27 June 1973, 1 ♀, L.M. Martin (CNC); 5 mi N Prescott, 7 July 1973, L.M. Martin, 1 ♂ (CNC); Granite Dells, 4 mi N Prescott, 8 Sep. 1971, L.M. Martin, 1 ♀ (CNC); Mayer, 4800 ft., 26 Apr. 1961, R.F. Sternitzky, 1 ♂ (AMNH); Prescott, 29 May 1907, R.E. Kunze, 1 ♂ (UCB), 2 Sep. 1907, 1 ♀, 8 Sep. 1907, 1 ♀, 1909, 1 ♀, R.E. Kunze (CNC), 30 May 1907, R.E. Kunze, 1 ♂ (SDNH); July 1910, O. Bucholz, 1 ♀ (CNC); Camp Verde, 11 June 1941, 1 ♀ (SDNH). Yuma Co.: Planet Mine, Bill Williams R., 24–31 May, 1 ♂; Welton, 1–6 Mar. 1925, 1 ♂, 3 ♀, O.C. Poling, 13 June 1939, 1 ♀, L.L. Stitt; Yuma, 22 July 1925, 3 ♂, 6 ♀; Martinez Lake, 10 June 1961, C.A. Toschi, 1 ♂ (UCB), 1 Apr. 1910, 1 ♀, 4 Apr. 1910, 1 ♂, L.R. Clemence (CNC), 9 Aug. 1941, W.P. Medlar, 1 ♂ (SDNH); Wellton, 14 Apr. 1938, F.H. Parker, 1 ♂ (CNC). Bill Wms. Fork, July, F.H. Snow, 3 ♀. No specific locality, 1–7 May 7 ♂, 4 ♀. Southern, 5 ♂, 6 ♀. Poling, 1 ♂, 1 ♀, Oslar. Washington Mts., B.P. Clark, 2 ♂, 3 ♀. CALIFORNIA: Imperial Co.: Dixieland, 1–15 Mar. 1922, 1 ♀, 15–30 Mar. 1922, 2 ♂, 5 ♀, 15–30 Apr. 1922, 1 ♂, 1–15 May 1922, 2 ♂, O.C. Poling; 16 mi NW Westmoreland, 2 Nov. 1974, J. Powell, 1 ♂ (UCB); Fish Creek Mts., 1 Apr. 1955, D.F. Hardwick 1 ♂ (CNC); Harpers Well, Mar. 1981, J. Smiley, 1 ♀ (UCB); Carrizo, 10 Mar. 1928, 1 ♀, 10 June 1928, 1 ♀, C.C. Searl (SDNH); 5 Apr. 1941, W.P. Medlar, 1 ♀ (SDNH). Inyo Co.: 1–15 Apr. 2 ♂, 1 ♀; 9 mi W Lone Pine, 19 July 1961, P.D. Hurd, J. Powell, 1 ♂ (UCB); Furnace Creek, Death Valley, 12 Apr. 1957, R.L.



- Langston, 1 ♂ (UCB); Shoshone, 9 Apr. 1962, R.W. Thorp, 1 ♀ (UCB); Surprise Canyon, Panamint Mts., 24 Apr. 1957, J. Powell, 1 ♀ (UCB); Tecopa, 7 June 1961, R.P. Allen, 1 ♂, 1 ♀ (UCB). Kern Co.: Taft, 28 Nov. 1942, 1 ♀ (CNC). Los Angeles Co.: Mt. Lowe, 8 July 1924, H.G. Dyar, 1 ♀; Santa Catalina Island, 20 Oct. 1932, D. Meadows, 1 ♂; 1 ♂, ♂ genitalia made VI-2-35 A.G. Richards, May 1 ♀, Coquillet; Pasadena, 16 June 1910, L.R. Clemence 1 ♂ (CNC); San Clemente Isl., Stone Biol. Sta., 4–6 Dec. 1981, J. Powell, 1 ♀ (UCB). Orange Co.: Warehouse, U.C. Irvine, 6 July 1969, 1 ♂ (UCB). Riverside Co.: Indio, 25 Feb. 1940, 3 ♂, 1 ♀, D. Meadows, 11, ♂ genitalia slide made VI-2-35 A.G. Richards, ♂ genitalia slide USNM 40524, 12, 13, 14, May 1921, 8 ♂, 3 ♀, E. Piazza; 2 mi N. of Desert Center, 31 Aug. 1946, C.I. Smith, 2 ♀ (UCB); 4 mi S Palm Desert, 2 July 1963, R.L. Langston, 2 ♂, 2 ♀ (UCB); 5 mi NW Palm Springs, 20 Sep. 1961, J.A. Chemsak, 1 ♀ (UCB); 6 mi N Desert Center, 31 Aug. 1946, C.I. Smith, 2 ♂ (UCB); Chino Canyon, Palm Springs, 10 June 1930, 1 ♀, 10 Apr. 1950, E.C. Johnston, 2 ♀ (CNC); Hopkins Well, 16 Apr. 1958, J. Powell, 2 ♂, 3 ♀ (UCB); Indio, 24 Feb. 1955, 1 ♂, 20 Apr. 1955, D.F. Harwick 1 ♂, 1 ♀ (CNC), 20 Apr. 1942, 1 ♀, 17, 20 May 1942, 2 ♀, 2 June 1942, 3 ♂, 1 ♀, 5 June 1942, 1 ♀, 30 June 1942, 1 ♀, W.P. Medlar (SDNH); Painted Canyon, near Mecca, 27 Mar. 1971, L. Orsak, 1 ♂ (UCB); Palm Springs, 3 Apr. 1932, 1 ♂, 10 Apr. 1934, 1 ♀ (CNC), 24 Jan. 1947, 1 ♀, 13 Oct. 1945, 1 ♀, C. Smith (UCB), 22 Mar. 1916, 1 ♀, 28 Mar. 1916, 1 ♂ C.L. Fox (SDNH); San Jacinto Mts., Pinyon Flat, 10 July 1967, J.W. Johnson, 2 ♂ (UCB); Thermal, 10 July 1956, M. Wassbauer, 1 ♀ (UCB); Thousand Palms, 14 Feb. 1955, 1 ♀, 29 Apr. 1955 1 ♂, 1 ♀, J.E.H. Martin (CNC); San Bernardino Co.: Loma Linda, 12 May 1912, 1 ♂, ♂ genitalia slide USNM 40523, G.R. Pilate, 8–15 Apr., 1 ♂, 1 ♀, ♂ genitalia slide USNM 46322, 8–15 May, 1 ♂, 16–23 May, 2 ♀, ♀ genitalia made VI-11-35 A.G. Richards, 8–15 June, 1 ♀; Coquillet; 10 mi NE Earp, 22 Apr. 1960, J.R. Powers, 2 ♂, 1 ♀ (UCB); 29 Palms, 21 Apr. 1950, E.C. Johnston 1 ♀ (CNC); 6 air mi W Rice, dunes, 1 Apr. 1978, J. Powell, R. Dietz, 1 ♀ (UCB); 9 air mi S Baker, Zzyzx Springs, 20 Apr. 1977, 2 ♂ 4 ♀, Chemsak & Powell, 21 Apr. 1977, 3 ♂, 2 ♀, Powell, 30 June 1978, 1 ♀, Powell (UCB); Apple Valley, 19 May 1955, J.E.H. Martin 1 ♀ (CNC); Cronise Lake, 26 Apr. 1937, H.B. Leech 1 ♀ (CNC); Cronise Vy., 29 Apr. 1956, J. Powell, 1 ♂ (UCB); Joshua Tree Nat. Mon., 15 mi S 29 Palms, 3600 ft., 19 Oct. 1966, D.F. Hardwick 4 ♂, 3 ♀ (CNC); Wheaton Springs, Ivanpah Mts., 18 July 1947, C. Smith, 1 ♀ (UCB). San Diego Co.: Jacumba, 22 June 1924, H.G. Dyar, 1 ♂ (USNM), 13 May 1978, 2 ♂, 26 Aug. 1979, 1 ♂, J.W. Brown, 20 July 1984, 3 ♀, 26 July 1980, 3 ♂, 9 Aug. 1980, 3 ♀, Faulkner & Brown, 4 Aug. 1980, 1 ♂, 1 ♀ (SDNH); Mason Valley, 22 Sep. 1935, D. Meadows, 1 ♀; S. Felipe Val., 5 Sep. 1937, D. Meadows, 1 ♀; San Diego, 30 Apr. 1924, H.G. Dyar, 1 ♂; 6 mi E Banner, 13 July 1963, J. Powell, 3 ♂ (UCB); Borego, 24 Feb. 1940, 1 ♀ Woodcock, Mar. 1947, N. Crickmer 1 ♀ (CNC); Borego, 21 Apr. 1960, 1 ♀, J.F. Lawrence, 3 May 1956, 1 ♂, J. Powell (UCB); Mt. Laguna, 4 mi NW, 5600', 3 Nov. 1966, D.F. Hardwick 1 ♂, 2 ♀ (CNC); Anza-Borrego Des. St. Pk., Grapevine Canyon, 25 Aug. 1986, Faulkner & Brown, 1 ♀ (SDNH); Boulevard-Manzanita, 10 June 1979, 1 ♂, 3 June 1980, 1 ♀, R. Messner (SDNH); NAS Miramar, Lep. Sur. Site 9, 11 July 1996, N. Broomfield, 1 ♂ (SDNH); Ocnaside, 5 Aug. 1957, A.A. Lee, 1 ♂ (SDNH); San Diego, 12 Oct. 1921, 1 ♀, June, 1 ♀, E. Piazza (SDNH); So. San Diego, 9 June 1978, 1 ♀ (SDNH). Stanislaus Co.: Del Rio, 26 Apr. 1922 1 ♀ (CNC). Werner Mts., 22 July 1922, 1 ♀, ex collection J.A. Comstock. La Puerta Valley, July 1911, G.H. Field, 1 ♂ (UCB), July 1911, G.H. Field, 2 ♂, 8 ♀ (SDNH). Warner's, Sep. 1919, G.H. Field, 1 ♀ (SDNH). No specific locality, 1 ♀. COLORADO: Boulder Co.: Boulder, Silver Saddle Motel, 5500', 8 June 1961, M.R. McKay, 1 ♂ (CNC). Fremont Co.: Canon City, 7 Aug. 1973, G.F. Hevel, 1 ♂. Prowers Co.: Two Buttes Dam, 21 July 1990, P.A. Opler, 1 ♂ (CSU). KANSAS: Finney Co.: Garden City, F.B. Miliken, 1 ♀. Greenwood Co.: Eureka, 13 July 1954, E.L. Todd, 3 ♀. Labette Co.: Oswego, 23 May 1964, 1 ♂, 4 June 1965, 1 ♀, G.F. Hevel. MISSISSIPPI: Hinds Co.: Jackson, 19 June 1960, B. Mather, 1 ♂ (BM); Clinton, 23 Mar. 1975, B. Mather, 1 ♂ (BM). Jackson Co.: Ocean Springs, 4 Aug. 1921, R.P. Barnhart, 1 ♂. Rankin Co.: Pearl, 14 July 1970, B. Mather, 1 ♀ (BM). MISSOURI: Benton Co.: Warsaw, 11 May 1962, J.R. Heitzman, 1 ♀. NEBRASKA: Cherry Co.: Hackberry Lake, Valentine N.W.R., 28 June 1983, D.C. Ferguson, 1 ♀. Platte Co.: Columbus, 24 June 1937, E.A. Froemel, 1 ♂. NEVADA: Clark Co.: Charlestown Mts., 1–15 July 1921, O.C. Poling, 1 ♂; Las Vegas, 15 June 1905, 1 ♂, 2, 14, 20 June 1905, 3 ♀, T. Spalding; 16–23 Mar., 1 ♀, 16–23 May, 1 ♀, 8–15 June, 3 ♂, 24–30 June, 1 ♂, 24–30 July, 1 ♀. Nye Co.: Mercury, 4 Aug. 1965, 1 ♂. NEW MEXICO: Bernalillo Co.: 15 mi E Albuquerque, 3 Sep. 1975, Lafontaine & Bowen 1 ♀ (CNC). Catron Co.: Gila Nat'l. Mon., 6000', 4 July 1964, D.R. Davis, 1 ♀. Chaves Co.: Roswell, Aug., Cockerell, 1 ♀, 12 June, on grape, 1 ♀, A.G. Hammar. Colfax Co.: 2 mi E Ute Park, 15–18 July 1974, E.L. Todd, 1 ♀; Cimarron Canyon, Sangre de Cristo Mts., 7900 ft., 11 July 1962, 1 ♂, E. & I. Munroe (CNC); Raton, 6600 ft., 5 July 1962, 1 ♂, 2 ♀, E.G. Munroe (CNC). Dona Ana Co.: Organ Mts., Finley Canyon, 5200 ft., 4 May 1979, R. Holland, 1 ♂, 1 ♀ (AMNH). Eddy Co.: Carlsbad, 17 May 1950, E.C. Johnston 1 ♀ (CNC); White City, 14 May 1950, 1 ♂, 15 May 1950, 1 ♀, H86 E.C. Johnston (CNC). Gaudalupe Co.: Santa Rosa, 12 July 1951, A.K. Wyatt, 1 ♀. Grant Co.: 2 mi SW Separ, 9 July 1964, J. Powell, 1 ♀ (UCB). Hidalgo Co.: Rodeo, 4 Sep. 1959, 1 ♂, D.D. Linsdale, 7 Sep. 1959, 1 ♂, J.R. Powers (UCB). Lincoln Co.: Cedar Creek Campground, Ruidoso, 7000', 28 July 1962, 1 ♂, 29 July 1962, 1 ♀, E. & I. Munroe (CNC). Luna Co.: Deming, 8–15 July, 3 ♂, 16–23 July, 7 ♂, 1 ♀, 1 ♀. McKinley Co.: McGaffey, 23 July 1962, 1 ♂, E. & I. Munroe (CNC); McGaffey, Zuni Mts., 7500 ft., 22 July 1962, 1 ♀, E. & I. Munroe (CNC). Otero Co.: High Rolls, Sep. 1 ♂, 2 ♀, ♂ genitalia made VI-3-35 A.G. Richards, 3 ♀; James Can., Sacramento Mts., 1 July 1940, D.G. Hall, 10 ♂, 9 ♀; Alamogordo, 10 May 1950, E.C. Johnston 1 ♀ (CNC). Quay Co.: Tucumcari, 25 June 1924, J.R. Horton, 1 ♂. Rio Arriba Co.: 2 mi E Gobernador, 6700', 20 Aug. 1971, D.F. Hardwick 1 ♀ (CNC). Sandoval Co.: Jemez Springs, 1 ♂; Frijoles Canyon, Bandelier Nat. Mon., 6050 ft, 18 July 1962, 1 ♂, 1 ♀, E. & I. Munroe (CNC). Socorro Co.: Socorro, 27 July 1962, 1 ♀, E. Munroe (CNC); Gran Quivira Nat'l Mon., 6600', 1–3 July 1964, 3 ♂, 5 ♀, D.R. Davis. Wemple, 8 July 1939, 1 ♂, 11 July 1939, 3 ♀, D. Meadows (USNM), 9 Sep. 1939, 1 ♂ (CNC). OKLAHOMA: Cleveland Co.: Norman, 18 May 1950, W.J. Reinthal 1 ♂ (CNC). Comanche Co.: Witchata Nat. Forest, 11 June 1926, T.H. Hubbell, 1 ♂, 2 ♀; Witchata Falls Nat. W. Ref., The Narrows, 10–18 July 1984, D. & M. Davis, 3 ♀. Love & Carter Cos.: Lake Murray, 20 May 1950, W.J. Reinthal 1 ♂, 2 ♀ (CNC). Murray Co.: Arbuckle Mts., 1 km W Turner Falls, 28 June–2 July 1984, D. & M. Davis, 2 ♀. Paine Co.: 1962, J.F. Reinert, 1 ♂. TEXAS: Bexar Co.: San Antonio, 5 ♂, 3 ♀, 2 ♂ genitalia slides USNM 40525, 46326, ♂ genitalia slide made XII-24-32 A.G. Richards, ♂ genitalia slide made VI-8-35 A.G. Richards, H. Schwarz, 1 ♀, 1–7 Apr., 1 ♀, June 1899, 1 ♀, July 1899, 1 ♀, O.C. Poling (USNM), 19 May 1939, Newman, 1 ♂, 1 ♀ (CNC). Blanco Co.: Blanco, 23 May 1963, A. & M.E. Blanchard, 1 ♀. Brazoria Co.: Churchill Bridge, 24 June 1962, A. & M.E. Blanchard, 1 ♂. Brewster Co.: Alpine, 2 ♂, 1928, 15–31 July 1926, 2 ♂, 2 ♂ genitalia made VI-5-35 A.G. Richards, 8–14 Aug. 1926, 1 ♀, ♀ genitalia made VI-12-35 A.G. Richards, 1926, 2 ♂, 1 ♀, 8–14 Mar. 1926, 1 ♀, 22–31 Mar. 1926, 1 ♀, 1–7 Apr. 1926, 3 ♀, 8–14 Apr. 1926, 3 ♀, 15–21 Apr. 1926, 4 ♂, 4 ♀, 22–30 Apr. 1926, 1 ♂, 1–7 May 1926, 2 ♂, 1 ♀, ♀ genitalia made VI-12-35 A.G. Richards, 8–14 May 1926, 5 ♀, 15–21 May 1926, 1 ♀, 1–7 June 1926, 1 ♀, 6–14 July 1926, 1 ♂, 15–21 July 1926, 2 ♂, 2 ♀, 22–31



July 1926, 2 ♂, O.C. Poling; Marathon, 7 June 1908, Mitchell & Cushman, 1 ♀ (USNM), 23 May 1950, E.C. Johnston, 1 ♀ (CNC); 1–7 Aug., 2 ♂, 15–30 Aug., 5 ♂, 3 ♀, 15–30 Aug. 1926, 1 ♀, O.C. Poling; Big Bend Nat. Park, 24 May 1950, E.C. Johnston 1 ♂, 1 ♀ (CNC); Hot Springs, Big Bend Nat. Park, 29 Apr. 1959, 1 ♂, M.R. MacKay, 6 May 1959, 1 ♀, L. Bottimer (CNC); Panther Jct., Big Bend Nat. Park, 19 May 1959, M.R. MacKay, 1 ♀ (CNC); The Basin, Big Bend Nat. Park, 4 May 1959, 1 ♂, 3 ♀, 8 May 1959, 1 ♂, 2 ♀, 10 May 1959, 2 ♀, 11 May 1959, 1 ♀, 16 May 1959, 1 ♀, M.R. MacKay (CNC). Burnet Co.: San Antonio, Shovel Mt., June 1899, O.C. Poling, 1 ♀, ♀ genitalia slide USNM 46327; Shovel Mt., 2 ♂, 2 ♀, 8–15 Apr., 1 ♂, 8–15 May, 1 ♀, 24–30 May, 1 ♀, 16–23 June 1 ♀. Cameron Co.: Brownsville, 2 ♂, Mar. 1911, 1 ♂, May 1911, 2 ♀, June 1911, 3 ♀, G. Dorner, 1 Apr. 1929, 1 ♀, 25 Apr. 1928, 1 ♀, 31 May 1915, 2 ♀, M.M. High, 1 Apr. 1929, 1 ♀, 25 Apr. 1928, 2 ♀, 7, 13, 22, 23, 24, 25, 26, 27, 29 May 1928, 4 ♂, 19 ♀, 25 Sep. 1928, 1 ♀, F.H. Benjamin, June 1911, 1 ♂, ♂ genitalia slide USNM 40521, G. Dorner, 12 Nov. 1968, 1 ♂, A. & M.E. Blanchard, 1 July 1895, 1 ♀, Townsend, 1–7 Aug. 1926, 1 ♀, O.C. Poling, 7 June 1904, 1 ♀, H.S. Barber; Brownsville, Esper Ranch, 1 ♀; San Benito, 7 ♀, 1–7 Apr., 1 ♂, 8–15 May, 3 ♂, 1 ♀, 16–23 May, 58 ♂, 30 ♀, 2 ♂ genitalia made VI-7-35 A.G. Richards, ♂ genitalia made VI-9-35 A.G. Richards, 2 ♀ genitalia made VI-11-35 A.G. Richards, 16–23 July 1 ♀, 8–15 Sept., 1 ♂, 1 ♀; Harlingen, 13 May 1958, J. Hunt, 2 ♂ (UCB). Chambers Co.: Black Jack Sprgs., 1 ♀. Cottle Co.: 8 mi NW Paducah, 1800, 23 Sep. 1968, 2 ♂, 24 Sep. 1968, 1 ♂, 1 ♀, D.F. Hardwick (CNC). Crane Co.: Crane, 28 May 1950, E.C. Johnston 2 ♂, 3 ♀ (CNC). Culberson Co.: Sierra Diablo, 20 mi NNW Van Horn, 27, 29 May 1973, D.C. Ferguson, 5 ♂, 4 ♀; Smith Cany., Guadalupe Mts., 5750', 22 May 1973, D.C. Ferguson, 1 ♀. Dallas Co.: Dallas, 22 May 1906, F.C. Pratt, 1 ♂, (USNM), 12 June 1942, C.I. Smith, 1 ♀ (UCB); vic. Irving, 29 Apr. 1984, 1 ♀, 6, 27 May 1984, 1 ♂, 2 ♀, 28 May 1983, 1 ♂, 1 ♀, 3, 23, 31 May 1981, 3 ♂, 3 ♀, 1 June 1980, 12 ♂, 3 June 1981, 2 ♂, 10 June 1983, 1 ♂, 10 June 1984, 1 ♂, 1 ♀, 22 June 1980, 1 ♀, R.A. Rahn; Irving, 15 Mar. 1953, Woodcock, 1 ♂ (CNC). Duval Co.: San Diego, 20 May 1895, bred from larva on Mesquite, E.A. Schwarz, 1 ♀. El Paso Co.: El Paso, 4000', 19, 24 June, 2 ♂, 6 Aug., 1 ♀, J. Woodgate (USNM), 26 May 1964, J.E.H. Martin, 1 ♀ (CNC). Gonzales Co.: Ottine, Palmetto St. Pk., 12–13 Aug. 1963, P.J. Spangler, 1 ♀. Harris Co.: July, 1 ♀; Houston, Aug. 1916, 1 ♂. Hemphill Co.: Canadien, Wldf. Mgt. Area Canadien, 11–12 July 1974, E.L. Todd, 1 ♂, 2 ♀. Hidalgo Co.: Donna, A.W. Nations, 1 ♀. Jeff Davis Co.: Davis Mtns., Mount Locke, 6700', 30 Aug. 1969, A. & M.E. Blanchard, 1 ♀; Davis Mtns. Resort, 5800', 27 Apr. 1992, D.G. Marqua, 1 ♂ (UCB); Ft. Davis, 29 May 1959, 2 ♂, 30 May 1959, 3 ♀, 31 May 1959, 1 ♂, 5 ♀, M.R. MacKay (CNC). Kerr Co.: Kerrville, 3 ♀, 11, 12 Apr. 1907, 1 ♂, 1 ♀, 30, 31 May 1906, 3 ♂, 6 ♀, ♂ genitalia made VI-2-35 A.G. Richards, 1 June 1906, 1 ♂, 2 ♀, F.C. Pratt, May 1912, 1 ♂, 1 ♀, H. Lacey, 16–23 Apr., 1 ♀, May 1903, 1 ♀, 17 May 1902, 1 ♀ (USNM), 5 Apr. 1959, 1 ♀, 15 Apr. 1959, 1 ♂, R.H. Wigmore (CNC). Kimble Co.: Junction, 3 Apr. 1968, A. & M.E. Blanchard, 1 ♂, 14–17, June 1972, 10 ♂, 9 ♀, D.C. Ferguson. La Salle Co.: Artesia Wells, 12, 13 June 1972, D.C. Ferguson, 3 ♂; Cotulla, Crawford & Pratt, 2 ♂, 2 ♂ genitalia made VI-8-35 A.G. Richards. Menard Co.: Menard, 25 July 1940, Hall, 2 ♂, 1 ♀. Nueces Co.: Corpus Christi, May, 1 ♂; Nueces River, 1 ♂, 26, 28, Apr. 1910, 2 ♂, F.C. Pratt, 22 June, 1 ♂, J. Doll. Pecos Co.: Ft. Stockton, 14 Aug. 1938, D. Meadows, 1 ♀. Presidio Co.: Presidio, 20 July 1944, ex. Prosopis, 1 ♂, 3 ♀; Shafter, 4000', 31 May 1973, D.C. Ferguson, 1 ♂, 1 ♀, 16 Oct. 1973, 1 ♀, A. & M.E. Blanchard. Randall Co.: Palo Duro Canyon State Pk., 15 Apr. 1969, A. & M.E. Blanchard, 1 ♂. Reeves Co.: Pecos, 6 Sep. 1952, 2 ♀, 8, 9 Sep. 1952, 2 ♂, R. Leuschner (USNM), 18 May 1950, E.C. Johnston 1 ♂, 1 ♀ (CNC). Robertson Co.: Calvert, G.H. Harris, 1 ♀. San Patri-

cio Co.: Sinton Welder Wildlife Foundation (San Patricio), 24, 25 May 1962, 1 ♂, 1 ♀, 22 June 1962, 3 ♀, ♀ genitalia slide USNM 46376, 22 Aug. 1962, 1 ♂, 1 ♀, 13 Sep. 1963, 1 ♂, 7 Oct. 1964, 2 ♀, ♀ genitalia slide USNM 46373, 13 Nov. 1963, 1 ♀, ♀ genitalia slide USNM 46374, A. & M.E. Blanchard. Terrell Co.: Sanderson, 27 Apr. 1959, 5 ♂, 2 ♀, M.R. MacKay, 28–29 Apr. 1959, 1 ♀, W.R.W. Mason (CNC). Travis Co.: Austin, 3 May 1897, H. Schwarz, 2 ♂, ♂ genitalia made VI-4-35 A.G. Richards; Bee Cave, 4 Sep. 1962, 1 ♂, 1 ♀, A. & M.E. Blanchard, ♂ genitalia slide USNM 46372. Uvalde Co.: Sabinal, 1 Apr. 1910, 1 ♂, 1 ♀, 26 May 1910, 1 ♀, F.C. Pratt. Victoria Co.: Victoria, 22 May 1915, 1 ♂, 18 June 1911, 1 ♀, J.D. Mitchell. Walker Co.: Huntsville S'te. Park, 19 May 1963, 1 ♀, A. & M.E. Blanchard, ♀ genitalia slide USNM 46375. Webb Co.: Laredo, 1 Aug. 1938, D. Meadows, 1 ♂, 1 ♀. Williamson Co.: Georgetown, 13 Apr. 1937, L.J. Milne, 1 ♂ (CNC). Belfrage, C.V. Riley, 1 ♀. 16 mi ESE Canyon, 3000', 26 Sep. 1968, D.F. Hardwick, 3 ♂, 1 ♀ (CNC). UTAH: Utah Co.: Vineland, 7 Aug. 1912, T. Spalding, 1 ♂. Washington Co.: St. George, 24–31 May, 1 ♀, 1–7 June, 1 ♂, 3 ♀, 8–15 June, 1 ♂.

**Larval host.** *Prosopis* sp. (Fabaceae). A female from the vicinity of Presidio, Texas in the USNM was reared.

**Distribution** (Fig. 61). Southern Manitoba, south to Nebraska and east to Mississippi, west to California and south to central Mexico.

**Discussion.** The type of *B. deducta* is the usual form the of male (Richards 1936a) (Fig. 25). The females have three distinct phenotypes. One is the maculate female that has all of the forewing pattern of the male, but is less distinct, and the median band and reniform spot are not as bright, but more infuscated with light brown (Figs. 26–27). The second is the immaculate female that was described as *B. pavitensis* (Figs. 28–29). The third form, *vulpina*, is a female with the terminal half of the forewing with cinnamon ground color (referred to as “dull foxy red” by Edwards (1882)) (Fig. 30). *Cirrhobolina incandescens* Grote is a large female and the form *albina* is a light female (Richards 1936a).

Collections indicate that *B. deducta* has a more migratory pattern than other species of *Bulia* based on the specimen record from southern Manitoba, Canada. There is a definite southern limit to the distribution in Mexico, from a line extending from the vicinity of Monterrey and Linares west to El Salto and Durango. A single stray specimen from southeastern Chiapas, Mexico, is probably a migrant.

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APPENDIX 1. Characters and character states used for phylogenetic analysis of *Bulia*; 0 = plesiomorphic state, 1–3 = apomorphic states. All characters were treated as ordered, with Figure numbers illustrating those character states.

1. Head	0—vertex of male without an elongate median projection 1—vertex of male with an elongate median projection (Fig. 3)
2. Head	0—labial palpus third segment not extending above vertex 1—labial palpus third segment extending above vertex
3. Hindwing	0—anal lunule white 1—anal lunule yellow
4. Eighth segment	0—tergum not reduced, mostly sclerotized 1—tergum reduced to a narrow X-shaped tergite, mostly membranous (Fig. 31)
5. Eighth segment	0—sternum not reduced, mostly sclerotized 1—sternum reduced to a wine glass shaped sternite, remainder membranous (Fig. 32)
6. Uncus	0—bearing long bifurcate setae 1—long bifurcate setae absent
7. Valva	0—clasper present 1—clasper absent
8. Valva	0—clavus present 1—clavus absent
9. Sacculus	0—lacking an expanded costal lobe 1—costal lobe small, triangular (Figs. 34–35) 2—costal lobe large, apex slightly bifurcate (Fig. 36) 3—costal lobe large, apex truncate to produced (Figs. 37–38)
10. Sacculus	0—apex not differentiated 1—apex not extending beyond cucullus 2—apex extending beyond cucullus, short (Figs. 34–35) 3—apex extending beyond cucullus, elongate (Figs. 36–38)
11. Juxta	0—dorsal margin slightly concave 1—dorsal margin U-shaped (Figs. 34–37 and 39–42) 2—dorsal margin V-shaped (Fig. 38 and 43)
12. Aedoeagus	0—external spiculations absent 1—external spiculations present (Figs. 47–48)
13. Vesica	0—lacking large spines 1—with 2 large spines (Figs. 44–45, 47–48) 2—with 1 large spine (Fig. 46)
14. Coremata	0—if present, arising from base of valva 1—arising from base of 8th tergum (Fig. 33)
15. Genital plate	0—not fused to the 7th sternum 1—fused to the 7th sternum
16. Median prong	0—absent 1—short, width greater than height (Figs. 49–51, 54–56) 2—long, width less than height (Figs. 52–53, 57–58)

APPENDIX 2. Data matrix for 2 outgroups, *Melipotis* (designated outgroup) and *Drasteria*, and species of *Bulia*. Character numbers refer to those in Appendix 1.

	1	11111	1
	12345 67890	12345	6
<i>Melipotis</i>	00000 00000	00000	0
<i>Drasteria</i>	01000 10001	00000	0
<i>confirmans</i>	11011 11112	10111	1
<i>mexicana</i>	11111 11112	10111	1
<i>schausi</i>	11111 11123	10211	1
<i>similaris</i>	11111 11133	11111	2
<i>deducta</i>	11111 11133	21111	2



## FRANCIS H. SNOW'S NEW MEXICO BUTTERFLY COLLECTIONS

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**ABSTRACT.** Francis H. Snow laid the foundation for scientific butterfly study in New Mexico. From his faculty post at the University of Kansas he led six natural history collecting expeditions into New Mexico between 1880 and 1894. These campaigns produced one butterfly species new to science, more than 90 state records, useful summary reports and labeled reference specimens. Butterflies collected on his first and last New Mexico expeditions are published here for the first time. Eighty labeled specimens from these six expeditions remain in the collections at the Snow Entomological Museum at the University of Kansas.

**Additional key words:** naturalist, natural history, collecting expedition, entomologist.

There was little systematic Lepidoptera study in New Mexico before the expeditions of entomologist Francis Huntington Snow. With so little known about its insect fauna, New Mexico must have seemed to Snow like an ideal destination. He was the first to conduct extensive butterfly collecting in New Mexico, the first to document detailed results in published reports, and the first to adequately label New Mexico specimens for future use. Snow's New Mexico contributions were first documented in published reports listing butterflies collected on expeditions in 1881, 1882 (Snow 1883), 1883 and 1884 (Snow 1885), which stood unquestioned for nearly 100 years.

It was the late 20th century before knowledge of the New Mexico butterfly fauna advanced to the point where some of Snow's published reports could be critically examined. In 1978, M. Toliver sought to confirm or refute certain inconsistencies by examining specimens in the collections at the Snow Entomological Museum (SEM) at the University of Kansas (UK). Toliver's determinations of dubious Snow reports helped consolidate historic knowledge of New Mexico and Rocky Mountain butterflies (Ferris & Brown 1980, Cary & Holland 1994, Toliver et al. 1994).

Snow published collection reports for New Mexico expeditions from 1881 through 1884 (Snow 1883, 1885). Snow (1883) briefly mentioned an 1880 New Mexico expedition, but implied that it produced no butterflies. He also mounted an expedition to New Mexico in 1894, for which he published Coleoptera collections (Snow 1907) but not Lepidoptera. Review of biographical material and re-examination of SEM collections in 1998, 2000 and 2002 confirmed that Snow collected butterflies in New Mexico in 1880 and 1894 and revealed details about those expeditions. Research also showed that Snow's expeditions of 1881 through 1884 produced more species than indicated in

his reports. Previously unreported collections are described below.

In this project, the authors profited from several sources of biographical information. Snow's biographer (Hyder 1953) listed all of Snow's scientific expeditions including his 1880 trip to Santa Fe Canyon and the 1894 trip to the Magdalena Mountains. Following Snow's death in 1908, Snow's colleagues eulogized him as a teacher, scientist and collector. Miller (1909), Marvin (1909), Stevens (1909) and Dyche (1909) provided valuable information and insights into Snow's character and methods. Snow belatedly published combined Coleoptera results from his six New Mexico collecting expeditions (Snow 1907). It is worthwhile now to do the same for his butterflies.

### FRANCIS HUNTINGTON SNOW

Born in 1840 in Fitchburg, Massachusetts, Francis H. Snow was raised with a strong work ethic and religious faith. His father was a staunch abolitionist who gave haven to escaped slaves on the Underground Railroad. Snow matured as the nation considered statehood for Missouri and Kansas; the Snows worked to keep Kansas slave-free. Snow was valedictorian of the Williams College class of 1862. Toward the end of the Civil War, he provided spiritual and hospital services for sick, wounded and dying soldiers.

Snow was classically trained and socially motivated, a practiced preacher and gifted educator. In 1866, five years after Kansas was admitted to the Union as a free state, Snow accepted a position with the newly founded University of Kansas in Lawrence. As one of the first three faculty members, he helped recruit students and assemble buildings, faculty and curricula. In 1868 Snow returned to Massachusetts, married Jane Aiken and brought her to Lawrence. He was devoted to his family, which eventually included six children.



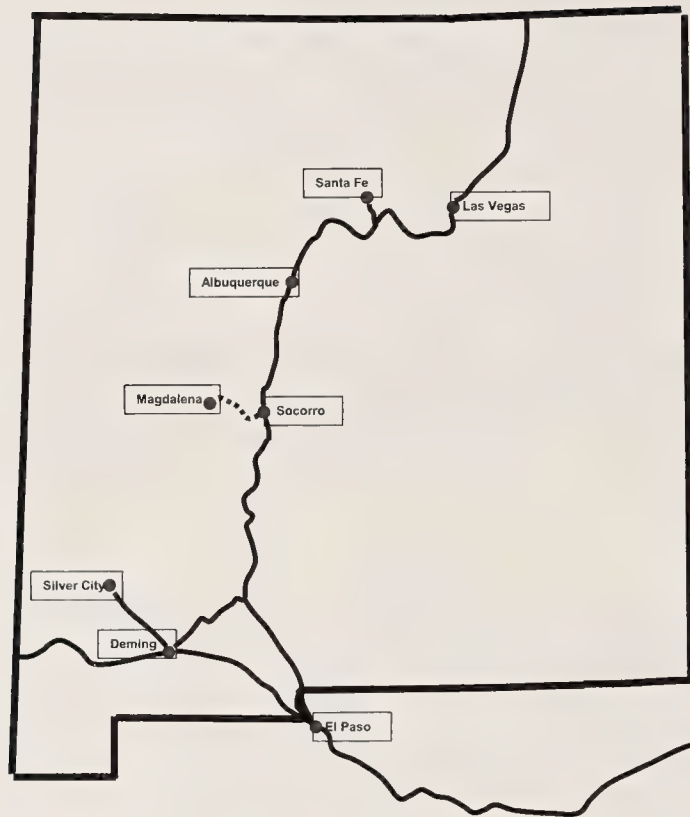


FIG. 1. Snow's New Mexico expedition locations and railroad lines ca. 1890.

Most of Snow's collecting excursions were family affairs and he corresponded with his wife when circumstances prevented her participation.

Snow taught every branch of natural science at UK. He had to teach himself first because his classical education did not include the many new scientific subjects. During his career Snow published more than 150 papers and reports. In 1890 Snow was named Chancellor of the UK. He served until 1901 when the strain of work and the untimely death of his first son forced him to cut back. Snow found solace and strength in the outdoors and, until his death in 1908, Snow did what he loved best—collecting, working with specimens, and teaching students about nature.

#### Collecting Expeditions

During his 42 years at UK, Snow lead 26 collecting expeditions to Kansas, Colorado, Texas, New Mexico and Arizona (Hyder 1953:279–280). For these expeditions, Snow sought out regions that offered opportunities for naturalists to discover and study new flora and fauna. Dyche (1909:40) explained that Snow's primary objective during these expeditions was "to make collections of insects, although he was interested in nearly every branch of natural history, and encouraged his assistants and students to collect birds, mammals, rep-

tiles, fishes and plants, as well as specimens of rocks, minerals and fossils."

Each expedition produced thousands of specimens (Miller 1909:24), which Snow examined upon his return. Varieties not represented in the UK collection were sent to specialists for determination. Specimens that enhanced the breadth of the UK collection ultimately were retained, but thousands of others ended up in the duplicate collection. Snow treated duplicates as assets to be sold or traded with collectors in the U.S. and Europe in return for other desirable specimens (Dyche 1909:44). Although his expeditions produced hundreds of insect species that were new to science, it appears that Snow himself described none (Dyche 1909:44).

#### 1880: Santa Fe Canyon, Sangre de Cristo Mountains

The 1880 UK expedition came by railroad (Fig. 1) to Santa Fe, the capital of New Mexico Territory (Snow 1881b). Snow brought his family (Jane, 11-year old son Willie and 10-year old daughter Mattie) and two student assistants, Louis L. Dyche and Annie E. Mozley. The group was in the field from August 6 to September 3. From their camp in the canyon of the Santa Fe River, they collected in the southwestern part of the Sangre de Cristo Mountains in Santa Fe County.

Confusion clouded the correct location of Snow's 1880 base camp. Snow first described it as "in Santa Fe canon" "eight miles from the city of Santa Fe, at an elevation of 7,000 feet" (Snow 1881b:67), then later as "eight miles north of Santa Fe" (1907:165). Dyche (1909:42) stated it most clearly: "Camp was located eight miles up the cañon from Santa Fé." Starting from the City at 7000 feet elevation on the Santa Fe River, eight miles up-canyon took Snow eastward to about 8000 feet elevation.

Arriving in Santa Fe in 1880, Snow found a landscape occupied by Spanish colonists almost continuously since ca. 1700. He traveled up the Santa Fe River along a well-worn trail first used by Indians, then by European settlers driving livestock to summer pasture (Fauntleroy 1999). Arrival of the transcontinental railroad in 1880 opened Santa Fe to nationwide economic markets, prompting local farmers to expand their herds. One year later near Snow's camp, the City constructed McClure Reservoir, which still remains part of the City's public water supply system (Fauntleroy 1999).

The published report for the 1880 expedition listed 273 species of Coleoptera, but no Lepidoptera (Snow 1881b). Instead, Snow remarked on the "conspicuous scarcity in Santa Fe canon . . . of the Lepidoptera, both diurnal and nocturnal," which he attributed to "nu-



TABLE 1. Butterflies collected during Snow’s 1880 expedition to Santa Fe Canyon, Santa Fe County, New Mexico. SEM = Snow Entomological Museum at the University of Kansas.

Taxon	Number of SEM specimens	Importance
<i>Erynnis pacuvius</i> (Lintner, 1878)	1	
<i>Apodemia nais</i> (W. H. Edwards, 1876)	1	1st NM specimen
<i>Speyeria hesperis</i> (W. H. Edwards, 1864)	2	1st NM specimens

merous flocks of sheep and goats, which destroy the food plants of these insects” (Snow 1881b:68).

Toliver’s 1978 review of SEM specimens revealed the first butterflies from this expedition (Table 1). He found two specimens of *Speyeria hesperis* (W. H. Edwards) and one of *Erynnis pacuvius* (Lintner) labeled from Santa Fe Canyon in August 1880. The senior author discovered a similar specimen of *Apodemia nais* (W. H. Edwards) while researching collections of the National Museum of Natural History (NMNH) in the 1980s. Recent review of the SEM collection revealed a second *A. nais* specimen with the 1880 label. Each specimen from this expedition is recognized by a typeset label reading “S. Fe Canon, N. M., 7000 ft., Aug., 1880 (Snow).”

1881: Water Canyon, Magdalena Mountains

Snow returned to New Mexico in August 1881. Prompted, perhaps, by the previous year’s disappointment, he ventured farther from civilization into wilder country, to Water Canyon in the northeast part of the Magdalena Mountains, Socorro County (Fig. 1). Snow’s 1881 crew included son Willie, Mr. Dyche and physics professor H. S. S. Smith.

As with much of south-central New Mexico at that time, the original Apache inhabitants still clung tenaciously to their lands, which included the Magdalena Mountains. The prospect of travel there may have given the Snow household reason for pause. This expedition began routinely, as Snow wrote to Jane on August 11: “. . . I was never before so far away from the railroad in camping out. We are 25 miles west of Socorro, New Mexico, so that it is entirely out of the question for any of us to go to town as we did at Santa Fe . . . Our camp is about 2 miles from the entrance to the cañon, near the log house of one John Smith who has lived here 8 years, during which time not a single Indian has entered the cañon . . . Willie is having a fine time and says he is glad he did not stay East. We both, however, miss you and the little girls sorely. . . Willie and I are getting lots of fine butterflies & other insects

& Dyche is putting up plants of which there are many new and beautiful species.”

Two days later, Snow’s idyll was shattered when a messenger, “who showed a bullet hole in his hat,” informed the group that the local Apaches had become hostile. Snow’s group assembled at a cabin with some miners and kept watch for three days (Hyder 1953:158–159). The group then headed for the safety of Socorro on a journey described by Snow: “We were asked to leave all our belongings in order to go down the cañon double-quick, but I could not see how a dozen or so of light cigar boxes filled with my bugs could endanger our march, so despite the wishes of the others I carried with me thirteen boxes of my bravest [finest] insects. I tied them up so I could get my arms around them and, putting my Boston Winchester over my shoulder, and with little Will, my boy, clinging to my sleeve, we started for Socorro . . . On the way down we found pools of blood where men had been murdered, and their wagons looted. Our teamster was one of the victims. A posse of 100 men coming out from Socorro met us and with them we continued our march down the cañon.”

The 1881 expedition retreated to areas that were safer, but less desirable for collecting. They spent three weeks near Socorro, one day at Deming and a week near Pecos (Dyche 1909:42). Snow (1883:36) referred his specimens to W. H. Edwards for determination. This troubled expedition produced more than two dozen species of butterflies from Water Canyon (Table 2) and one from Deming, but none from Socorro or Pecos (Snow 1883). Each Water Canyon specimen in the SEM was identified based on a single typeset label stating: “Water Canon, N. M., 5000 ft., Aug. ’81, F. H. Snow.”

1881 is the first year for which Snow’s reports can be compared against extant specimens. Allowing for nomenclature changes, they match pretty well. The few discrepancies are understandable after more than a century of taxonomic progress. Snow’s report of *E. funeralis* (Scudder & Burgess) probably was the similar *Erynnis tristis tatus* (W. H. Edwards), which was not described until 1882 (Ferris & Miller 1980:21) but for which there is an 1881 SEM specimen. He also reported *Erynnis martialis* (Scudder), which is impossible (see Cary & Holland 1992[1994]). He probably had *E. afranius* (Lintner) based on size, markings, habitat and voltinism, but this remains speculation until a specimen is located. The final 1881 mystery concerns *Brephidium exile* (Boisduval). Snow (1883) reported it only from Deming, but the 1881 SEM specimen has a Water Canyon label.

Snow’s labeled elevation represented the mouth of



TABLE 2. Butterflies collected during Snow's 1881 expedition to Water Canyon, Magdalena Mountains, Socorro County, New Mexico.

Taxon	Reported by Snow (1883) as	Number of SEM <sup>1</sup> specimens	Importance
<i>Erynnis pacuvius</i> (Lintner, 1878)	Thanaos Pacuvius Lintn.		
<i>Erynnis tristis</i> (Boisduval, 1852)			
ssp. <i>tatius</i> (W. H. Edwards, 1882)	Thanaos funeralis Scud.-B.	1	1st NM specimen
? <i>Erynnis afranius</i> (Lintner, 1878)	Thanaos Martialis Scud.		1st NM report
<i>Pholisora catullus</i> (Fabricius, 1793)	Pholisora catullus Cram.		1st NM report
<i>Piruna pirus</i> (W. H. Edwards, 1878)	Pholisora Pirus Edw.	1	1st NM specimen
<i>Pterourus multicaudatus</i> (W.F. Kirby, 1884)	Papilio Daunus Edw.		1st NM report
<i>Pterourus rutulus</i> (Lucas, 1852)	Papilio Rutulus Bd.		1st NM report
<i>Zerene cesonia</i> (Stoll, 1790)	Colias Caesonia Stoll		1st NM report
<i>Phoebis sennae</i> (Linnaeus, 1758)			
ssp. <i>eubule</i> (Linnaeus, 1767)	Callidryas Eubule L.		1st NM report
<i>Eurema mexicana</i> (Boisduval, 1836)	Terias Mexicana Bd.		1st NM report
<i>Eurema nicippe</i> (Cramer, 1779)	Terias Nicippe Cram.		1st NM report
<i>Nathalis iole</i> Boisduval, 1836	Nathalis Iole Bd.		1st NM report
<i>Hypaurotis crysalus</i> (W. H. Edwards)	Thecla Crysalus Edw.		1st NM report
<i>Brephidium exile</i> (Boisduval, 1852)	not reported	1	1st NM specimen
<i>Everes amyntula</i> (Boisduval, 1852)	Lycaena Amyntula Bd.		1st NM report
<i>Plebejus lupini</i> (Boisduval, 1869)	Lycaena Acmon West-Hew.		1st NM report
<i>Euptoieta claudia</i> (Cramer, 1775)	Euptoieta Claudia Cram.		1st NM report
<i>Chlosyne lacinia</i> (Geyer, 1837)			
ssp. <i>crocale</i> (W. H. Edwards, 1874)	Synchlœ Crocale Edw.		1st NM report
<i>Phyciodes pictus</i> (W. H. Edwards, 1865)	Phyciodes picta Edw.		1st NM report
<i>Polygonia gracilis</i> Grote and Robinson, 1867			
ssp. <i>zephyrus</i> (W. H. Edwards, 1870)	Grapta Zephyrus Edw.	1	1st NM specimen
<i>Nymphalis milberti</i> (Godart, 1819)	Vanessa Milberti Godt.		1st NM report
<i>Vanessa virginiensis</i> (Drury, 1773)	Pyrameis Huntera Drury		1st NM report
<i>Vanessa cardui</i> (Linnaeus, 1758)	Pyrameis cardui L.		1st NM report
<i>Limenitis weidemeyerii</i> (W.H. Edwards, 1861)	Limenitis Weidemeyerii Edw.		1st NM report
<i>Adelpha bredowii</i> Geyer, 1837	Heterochroa Californica But.	1	1st NM specimen
<i>Cyllopsis pertepida</i> (Dyar, 1912)	Neonympha Henshawii Edw.	2	1st NM specimens
<i>Cercyonis meadii</i> (W. H. Edwards, 1872)	Satyrus Meadii Edw.		1st NM report
<i>Danaus plexippus</i> (Linnaeus, 1758)	Danaïs Archippus Fab.		1st NM report
<i>Danaus gilippus</i> (Cramer, 1775)	Danaïs Berenice Cram.		1st NM report

<sup>1</sup> SEM = Snow Entomological Museum at the University of Kansas.

the canyon rather than the whole area sampled, as it did for Santa Fe Canyon in 1880. Water Canyon crosses the 5000-foot contour in open desert grassland, but Snow camped two miles above the canyon mouth at about 8000 feet elevation. In addition to SEM specimens from this expedition, the American Museum of Natural History (AMNH) appears to have three specimens of *Cyllopsis pertepida* (Dyar), cited by Miller (1974:72).

1882: Gallinas Canyon, Sangre de Cristo Mountains

In 1882 Snow traveled to Gallinas Canyon, which begins in the southern portion of the Sangre de Cristo Mountains and descends southeastward through Las Vegas, in San Miguel County (Fig. 1). Arrival of the railroad in 1879 changed Las Vegas from a quiet farming village to a busy railroad town. Construction of a resort hotel near the hot springs in 1880 quickly made

Las Vegas an international destination for consumptives and other health seekers.

The 1882 group, consisting of Snow, his family and three university students: Mr. Dyche, Mary Dyche, and Mr. W. W. Russ, produced more butterfly records than Snow's other New Mexico adventures. In Gallinas Canyon, Snow found a "naturalist's paradise" compared to the 1880 expedition and a safe haven compared to the expedition of 1881. "The occupancy of the mouth of the cañon by hotels and bathing-houses of that famous sanitarium, has proved an effectual barrier against the entrance of troublesome ruminants, and the entomologist and botanist is able to obtain the choicest of his favorite objects of study in delightful variety and perfection" (Snow 1883:35).

After nine weeks of collecting, Snow (1883) reported about 50 butterfly taxa (Table 3). From this expedition, the SEM retains 30 specimens representing



27 species, including three not given in Snow's report. Most specimens bear typeset labels stating: "Near Hot Springs, Las Vegas, N.M., 7000 ft., July, '82, F. H. Snow." Others give the date of collection as "Aug. '82." Two reported species, *Pieris sisymbrii* (Boisduval) and *Anthocharis sara* Lucas, fly only in spring; an SEM specimen of the former has "April" inked in longhand over the typeset "July." Archival materials suggest that Snow had an associate in Las Vegas who could have obtained these specimens in the proper season.

Once again, Snow's party explored a range of elevations not reflected on the specimen labels. Collecting at about 6800 feet elevation in foothill canyons near the Hot Springs probably produced Upper Sonoran Zone species like *Amblyscirtes aenus* W. H. Edwards. Gallinas Creek and its tributaries continue upstream from there, climbing gradually for more than 20 miles through Transition Zone into Canadian Zone habitats. Snow's group likely traveled this route, visiting elevations near 10,000 feet elevation to collect *Speyeria mormonia* Boisduval, *Oeneis chryxus* (Doubleday & Hewitson) and *Erebia epipsodea* Butler.

There are a few mismatches between SEM specimens and Snow (1883) reports (Table 3), primarily among the Hesperidae. Snow reported *Thorybes bathyllus* (J. E. Smith), but the SEM specimen so labeled is actually *T. pylades* (Scudder). There also is confusion among the *Erynnis* spp., which were not well known at the time. An SEM specimen of *E. horatius* (Scudder & Burgess) is mislabeled as *E. martialis* (Scudder), yet neither can be linked conclusively to the reported *E. juvenalis* (Fabricius), which is erroneous. Among the SEM specimens labeled to the 1882 expedition are three that Snow (1883) did not report (Table 3).

Snow collected the type series of *Hesperia viridis* (W. H. Edwards) in 1882 during a period when skippers once lumped with Old World *Hesperia comma* (Linnaeus) were being differentiated and described. Amid this taxonomic instability, Snow (1883) reported collecting "*Pamphila Comma* n. var." Edwards (1883) described the male "sent me by Prof. Snow and taken by him at Los Vegas [sic], N. M., in 1882" and called it "var. *Viridis*." This was the only new taxon described using butterflies collected in New Mexico by Snow.

Two specimens found by F. M. Brown in the AMNH in the 1970s may be traceable to the 1882 expedition. A single specimen of *Euphyes vestris* (Boisduval) appears to have the distinctive Snow label for that expedition (Toliver et al. 1994:112). A specimen of *Hemiargus ceraunus* (Fabricius) is similarly labeled, but is dated "Sept." (Toliver et al. 1994:258). Each has a label indicating that it came to the AMNH via the Hulst collection.

### 1883: Gallinas Canyon, Sangre de Cristo Mountains

The butterfly collections of the 1883 expedition remain a mystery. Snow (1885) stated that in "July and August, 1883, our collections were made in the same locality as 1882—the Gallinas cañon, near the Las Vegas Hot Springs. My assistants were Messrs. L. L. Dyche, W. H. Brown, W. C. Stevens, and [my son] W. A. Snow." Lists of Lepidoptera and Coleoptera published for this trip included only those species that were not reported from 1882 (Snow 1885). Apparently no butterflies satisfied this criterion because none were listed among the many beetles and moths. Similarly, the SEM contains no butterfly specimens with labels traceable to this expedition. Snow's decision to neither report duplicates nor retain them in the collection would have been consistent with his normal practice.

### 1884: Walnut Canyon and Elk Mountain

The 1884 expedition included the same people as in 1883, but this time they split into two groups and produced butterflies from two geographically and ecologically distinct localities. Dyche and Brown detrained at Las Vegas and returned to the site of their successful 1882 and 1883 campaigns. Prof. Snow, his son Willie and W. C. Stevens traveled to Silver City in the southwest corner of New Mexico (Fig. 1). As far as we have been able to ascertain, and in contrast to previous expeditions, the 1884 butterfly specimens are not labeled to indicate month, year and locality of capture. Perhaps material from the two parties became mixed at some point, placing in doubt the provenance of individual specimens. Because Snow returned with butterflies unique to southwestern New Mexico and reported them (Snow 1885), the authors were able to propose below a consistent labeling scheme for the 1884 specimens.

**Little Walnut Creek.** Snow "encamped about twelve miles north of Silver City, on the Walnut Creek, some three miles west of the divide which separates the Atlantic and Pacific slopes" (Snow 1885:65) (Fig. 1). This coincides today with the Gila National Forest's Little Walnut Creek Picnic Ground, at about 6500 feet elevation in the Pinos Altos Mountains.

Snow's entire report for 1884 listed just 13 species of butterflies, all from Little Walnut Creek (Table 4a). His list was short considering that the area supports well over 100 species (e.g., Hubbard 1965, Ferris 1976, Zimmerman 2001) and that summer rains usually make August a productive month. Snow (1885:69) explained that "the season was a very dry one, there being hardly enough rain, except on one occasion, to thoroughly wet the canvas of our tent in the Walnut



TABLE 3. Butterflies collected during Snow's 1882 expedition to Gallinas Canyon, San Miguel County, NM.

Taxon	Reported by Snow (1883) as	Number of SEM <sup>1</sup> specimens	Importance
<i>Thirybes pylades</i> (Scudder, 1870)	Eudamus Pylades <i>Scud.</i>	1 <sup>2</sup>	1st NM specimen
<i>Erynnis horatius</i> (Scudder & Burgess, 1870)	not reported	1 <sup>3</sup>	1st NM specimen
<i>Erynnis pacuvius</i>	Thanaos juvenalis <i>F.</i> <sup>4</sup> Thanaos Pacuvinus <i>Lintn.</i>		
<i>Pyrgus communis</i> (Grote, 1872)	Pyrgus tessellata <i>Scud.</i>		1st NM report
<i>Oarisma edwardsii</i> (Barnes, 1897)	not reported	1 <sup>5</sup>	1st NM specimen
<i>Oarisma garita</i> (Reakirt, 1866)	Thymelicus Hylax <i>Edw.</i>	1	1st NM specimen
<i>Hesperis comma</i> (Linnaeus, 1758)	Pamphila Comma var. Juba <i>Scud.</i> <sup>6</sup>		
<i>Hesperia viridis</i> (W. H. Edwards, 1883)	Pamphila Comma n. var.		
<i>Polites themistocles</i> (Latreille, 1824)	Pamphila Cernes <i>Bd.-Lec.</i>	1	1st NM specimen
<i>Poanes taxiles</i> (W. H. Edwards, 1881)	Pamphila Taxiles <i>Edw.</i> <sup>7</sup>	2	1st NM specimens
<i>Paratrytone snowi</i> (W. H. Edwards, 1877)	Pamphila Snowi <i>Edw.</i>		1st NM report
<i>Euphyes vestris</i> (Boisduval, 1852)	Pamphila Metacomet <i>Harr.</i> <sup>8</sup>		1st NM report
<i>Amblyscirtes aenus</i> W. H. Edwards, 1878	Amblyscirtes aeneus <i>Edw.</i>		1st NM report
<i>Amblyscirtes cassus</i> W. H. Edwards, 1883	not reported	1	1st NM specimen
<i>Amblyscirtes phylace</i> (W. H. Edwards, 1878)	Pamphila Phylace <i>Edw.</i>	2	1st NM specimens
<i>Pterourus multicaudatus</i> (W. F. Kirby, 1884)	Papilio Daunus <i>Edw.</i>	1	
<i>Pterourus rutulus</i> (Lucas, 1852)	Papilio Rutulus <i>Bd.</i>	1	
<i>Neophasia menapia</i> (C. and R. Felder, 1859)	Pieris Menapia <i>Feld.</i>		1st NM report
<i>Pontia sisymbrii</i> (Boisduval, 1852)	Pieris Sisymbri <i>Bd.</i>	1	1st NM specimen
<i>Pontia occidentalis</i> (Reakirt, 1866)	Pieris occidentalis <i>Reak.</i>		1st NM report
<i>Pieris napi</i> (Linnaeus, 1758)	Pieris oleracea <i>Bd.</i> <sup>9</sup>	1	1st NM specimen
<i>Anthocharis thoosa</i> (Scudder, 1878)	Anthocharis Thoosa <i>Scud.</i>	1	1st NM specimen
<i>Euchloe ausonides</i> (Lucas, 1852)	Anthocharis Ausonides <i>Bd.</i>	1	1st NM specimen
<i>Colias eurytheme</i> Boisduval, 1852	Colias Eurytheme <i>Bd.</i>		1st NM report
<i>Zerene cesonia</i> (Stoll, 1790)	Colias Caesonia <i>Stoll.</i>		
<i>Nathalis iole</i> Boisduval, 1836	Nathalis Iole <i>Bd.</i>		
<i>Lycaena arota</i> (Boisduval, 1852)	Chrysophanus Ianthe <i>Edw.</i>	1	1st NM specimen
<i>Lycaena helloides</i> (Boisduval, 1852)	Chrysophanus helloides <i>Bd.</i>	1	1st NM specimen
<i>Hypaurotis crysalus</i> (W. H. Edwards, 1873)	Thecla Crysalus <i>Edw.</i>		
<i>Satyrium calanus</i> (Hübner, 1809)	Thecla Calanus <i>Hubn.</i>	2	1st NM specimens
<i>Satyrium behrii</i> (W. H. Edwards, 1870)	Thecla Behrii <i>Edw.</i>		1st NM report
<i>Callophrys affinis</i> (W. H. Edwards, 1862)	Thecla Apama <i>Edw.</i>	1	1st NM specimen
<i>Mitoura grynea</i> (Hübner, 1819)			
ssp. <i>siva</i> (W. H. Edwards, 1874)	Thecla Siva <i>Edw.</i>	1	
<i>Incisalia eryphon</i> (Boisduval, 1852)	Thecla Eryphon <i>Bd.</i>	1	1st NM specimen
<i>Leptotes marina</i> (Reakirt, 1868)	Lycaena marina <i>Reak.</i>		1st NM report
<i>Everes amyntula</i> (Boisduval, 1852)	Lycaena Amyntula <i>Bd.</i>		
<i>Glaucopsyche lygdamus</i> (Doubleday, 1841)			
ssp. <i>oro</i> (Scudder, 1876)	Lycaena Lygdamus var. Oro <i>Scud.</i>		1st NM report
<i>Lycaeides melissa</i> (W. H. Edwards, 1873)	Lycaena Melissa <i>Edw.</i>		1st NM report
<i>Icaricia lupini</i> (Boisduval, 1869)	Lycaena Acmon <i>West-Hew.</i>		
<i>Agriades franklinii</i> (Curtis, 1835)	Lycaena orbitulus <i>Von Pr.</i>	1	1st NM specimen
<i>Apodemia nais</i> (W. H. Edwards, 1876)	Nemeobius Nais <i>Edw.</i>	1	
<i>Euptoieta claudia</i> (Cramer, 1775)	Euptoieta Claudia <i>Cram.</i>	1	
<i>Speyeria aphrodite</i> (Fabricius, 1787)			
ssp. <i>ethne</i> (Hemming, 1933)	Argynnis Alcestis <i>Edw.</i>	1	1st NM specimen
<i>Speyeria hesperis</i> (W. H. Edwards, 1864)			
ssp. <i>electa</i> (W. H. Edwards, 1878)	Argynnis Electa <i>Edw.</i>		
<i>Speyeria mormonia</i> (Boisduval, 1869)			
ssp. <i>eurynome</i> (W. H. Edwards, 1872)	Argynnis Eurynome <i>Edw.</i>	1	1st NM specimen
<i>Poladryas minuta</i> (W. H. Edwards, 1861)	Melitaea minuta <i>Edw.</i>		1st NM report
<i>Thessalia fulvia</i> (W. H. Edwards, 1879)	Melitaea Fulvia <i>Edw.</i>	1	1st NM specimen
<i>Chlosyne nycteis</i> (Doubleday and Hewitson, 1847)	Phyciodes Nycteis var.		1st NM report
<i>Phyciodes cocyta</i> (Cramer, 1777)	Phyciodes Tharos n. var. <sup>10</sup>		1st NM report
<i>Phyciodes pratensis</i> (Behr, 1863)			
ssp. <i>camillus</i> W. H. Edwards, 1871	Phyciodes Camillus <i>Edw.</i>		1st NM report
<i>Euphydryas anicia</i> (Doubleday and Hewitson 1848)	Melitaea Nubigena <i>Behr</i>		1st NM report
<i>Polygonia gracilis</i> (Grote and Robinson, 1867)			
ssp. <i>zephyrus</i> (W. H. Edwards, 1870)	Grapta Zephyrus <i>Edw.</i>		



TABLE 3. Continued.

Taxon	Reported by Snow (1883) as	Number of SEM <sup>1</sup> specimens	Importance
<i>Nymphalis milberti</i> (Godart, 1819)	Vanessa Milberti <i>Godt.</i>		
<i>Nymphalis antiopa</i> (Linnaeus, 1758)	Vanessa Antiopa <i>L.</i>		1st NM report
<i>Nymphalis californica</i> (Boisduval, 1852)	Vanessa Californica <i>Bd.</i>	1	1st NM specimen
<i>Vanessa virginiensis</i> (Drury, 1773)	Pyrameis Huntera <i>Drury</i>		
<i>Vanessa cardui</i> (Linnaeus, 1758)	Pyrameis cardui <i>L.</i>		
<i>Limnitis weidemeyerii</i> (W. H. Edwards, 1861)	Limnitis Weidemeyerii <i>Edw.</i>		
<i>Cyllopsis pertepida</i> (Dyar, 1912)	Neonympha Henshawii <i>Edw.</i>		
<i>Coenonympha ochracea</i> W. H. Edwards	Coenonympha ochracea <i>Edw.</i>		1st NM report
<i>Cercyonis pegala</i> (Fabricius, 1775)	Satyrus Nephele <i>Kirby</i>		1st NM report
<i>Cercyonis oetus</i> (Boisduval, 1869)			
ssp. <i>charon</i> (W. H. Edwards, 1872)	Satyrus Charon <i>Edw.</i>		1st NM report
<i>Erebia epipsodea</i> Butler, 1868	Erebia epipsodea <i>Butler</i>		1st NM report
<i>Neominois ridingsii</i> (W. H. Edwards, 1865)	Hipparchia Ridingsii <i>Edw.</i>		1st NM report
<i>Oeneis chryxus</i> (Doubleday and Hewitson, 1849)	Chionobas Uhleri <i>Reak.</i>		1st NM report
<i>Danaus plexippus</i> (Linnaeus, 1758)	Danaus Archippus <i>Fab.</i>		
<i>Danaus gilippus</i> (Cramer, 1775)	Danaus Berenice <i>Cram.</i>		

<sup>1</sup> SEM = Snow Entomological Museum at the University of Kansas.  
<sup>2</sup> Snow also reported “Eudamus Bathyllus *Sm.-Abb.*” This specimen of *T. pylades* has an old label misidentifying it as *T. bathyllus*.  
<sup>3</sup> An old label misidentifies this specimen as *E. martialis* (Scudder), which Snow (1883) did not report.  
<sup>4</sup> *E. juvenalis* does not occur in New Mexico; without a specimen, there is no way to know to what Snow referred.  
<sup>5</sup> An old label misidentifies this specimen as *O. garita*.  
<sup>6</sup> Although no specimen was found, this was likely a routine *H. comma* rather than a range-extending *H. juba* (Scudder).  
<sup>7</sup> Snow also reported “Poanes Zabulon *Bd.-Lec.*” which does not occur in New Mexico.  
<sup>8</sup> Snow also reported “Pamphila bimacula *Gr.-Rob.*” which does not occur in New Mexico.  
<sup>9</sup> Snow also reported “Pieris Napi var. *pallida Scud.*,” which was synonymized.  
<sup>10</sup> Snow also reported “Phyciodes tharos var. *Marcia Edw.*,” which refers to the same species.

creek cañon during a stay of five weeks. The bed of the creek was dry for long distances.” Eight of the 13 species reported by Snow (1885) were found in the SEM collection, each pinned to a label tersely typeset in black ink stating merely “New Mexico. F. H. Snow.”

In 2002, the SEM had 15 additional specimens with “New Mexico. F. H. Snow.” labels, which Snow (1885) did not report. Habitat preferences and geographic distributions (e.g., Cary & Holland 1994, Toliver et al. 1994) suggest that Little Walnut Creek was the only one of Snow’s New Mexico destinations capable of producing several species bearing the “New Mexico” labels (Table 4b). These additional 11 species bring the 1884 Little Walnut Creek catch to 24 species. To that it seems reasonable to add a small series of *Cyllopsis pertepida* specimens in the AMNH with like “New Mexico” labels (Miller 1974:72). Together, these specimens support a common origin for the “New Mexico. F. H. Snow.” labels.

Among the final tally for Snow’s Little Walnut Creek party were three new species: *Atrytonopsis lunus* (W. H. Edwards), *Piruna polingii* (Barnes) and *Erynnis meridianus* Bell, which were described in 1884, 1900 and 1927, respectively (Miller & Brown 1981). The biggest surprise was *Eurema salome* (C. Felder & R. Felder), a subtropical stray for which Snow’s specimen

remains the only New Mexico record. This specimen was attributed to New Mexico by Ehrlich and Ehrlich (1961:64) but without substantiating data, leaving recent workers skeptical (e.g., Scott 1986:207, Toliver et al. 1994:203). The specimen in question was in the SEM in 2002 pinned to a “New Mexico. F. H. Snow.” label and to a second label stating it was “illustrated in Ehrlich’s ‘How to Know the Butterflies’.”

**Elk Mountain.** Gallinas Canyon was the starting point for the other section of the 1884 expedition, which apparently did no collecting there. Dyche explained that his party “collected part of the summer at Harvey’s ranch, on top of ‘Baldy’ mountain, about twenty-five miles northwest of Las Vegas” (Dyche 1909:43). The Harvey property is at 9500 feet elevation near the head of Cascade Canyon, a tributary to Gallinas Creek (U.S. Forest Service 1994). From there, Elk Mountain was a brief six-mile horseback ride to the west. At 11,700 feet elevation, Elk Mountain is the nearest peak sufficiently treeless to qualify as “bald.” Dyche and Brown traveled on, spending “about six weeks of our time thirty to forty miles to the northwest of Harvey’s ranch, on the head waters of the Pecos river” (Dyche 1909:43). There is no suggestion that they reached the highest peaks, which exceed 13,000 feet elevation.



TABLE 4A. Butterflies collected during Snow's 1884 expedition to Little Walnut Creek as reported by Snow (1885).

Taxon	Reported by Snow (1885) as	Number of SEM <sup>1</sup> specimens	Importance
<i>Autochton cellus</i> (Boisduval and Leconte, 1837)	<i>Eudamus cellus</i> Bd.-Lec.		1st NM report
<i>Cogia caicus</i> (Herrich-Schäffer, 1869) ssp. <i>moschus</i> (W. H. Edwards, 1882)	<i>Eudamus moschus</i> Edw.	1	1st NM specimen
<i>Erynnis pacuvius</i> (Lintner, 1876)	<i>Thanaos pacuvius</i> Lintn.		
<i>Piruna polingii</i> (Barnes, 1900)	<i>Pholisora</i> , n. sp.	1	1st NM specimen
<i>Amblyscirtes aenus</i> W. H. Edwards, 1878	<i>Amblyscirtes aenus</i> Edw.		
<i>Atrytonopsis lunus</i> (W. H. Edwards, 1884)	<i>Pamphila lunus</i> Edw.	1	1st NM specimen
<i>Battus philenor</i> (Linnaeus, 1771)	<i>Papilio philenor</i> L.	1	1st NM specimen
<i>Atlides halesus</i> (Cramer, 1777)	<i>Thecla halesus</i> Cram.		1st NM report
<i>Erora quaderna</i> (Hewitson, 1868)	<i>Thecla laeta</i> Edw.	1	1st NM specimen
<i>Leptotes marina</i> (Reakirt, 1868)	<i>Lycaena marina</i> Edw.	1	
<i>Hemiargus isola</i> (Reakirt, 1866)	<i>Lycaena alce</i> Edw.	1	1st NM specimen
<i>Celastrina ladon</i> (Cramer, 1780)	<i>Lycaena neglecta</i> Edw.	1	1st NM specimen
<i>Limenitis arthemis</i> (Drury, 1773) ssp. <i>arizonensis</i> (W. H. Edwards, 1882)	<i>Limenitis ursula</i> Fab. var. <i>Arizonensis</i> Edw.		1st NM report

<sup>1</sup> SEM = Snow Entomological Museum at the University of Kansas.

The expedition report (Snow 1885) listed no butterflies collected by this party, but we believe a few butterflies captured by Dyche and Brown reside in the SEM collection, linked to the 1884 expedition by vague “New Mexico. F. H. Snow.” labels (Table 4c). Their habitat requirements associate them with the Canadian Zone west of Las Vegas, rather than the Upper Sonoran and Transition Zone habitats of Little Walnut Creek. Some of these species also were caught by the 1882 expedition (Table 3).

The “New Mexico. F. H. Snow.” labels may always be somewhat problematic. One could argue that certain individual specimens with that label match up with published reports from 1881 or 1882. But it seems unlikely that the careful Snow would attach vague labels to one specimen in lieu of the informative labels pinned to the other specimens from that expedition. Seeking parsimony for the “New Mexico. F. H. Snow.” labels, we suggest that they were printed for and affixed to one lot of specimens. 1884 was the only year that could have produced all those specimens and no specimens from 1884 are otherwise labeled.

What might have prompted Snow to attach such general labels to this lot? Snow was a notoriously hard worker who accepted all challenges, leaving less time for his collections (Dyche 1909:43). In the early 1880s Snow taught botany, zoology, geology, natural history, meteorology and comparative anatomy—a burden of classes “which ought to have been taught by four men” (Hyder 1953:143). He also helped Kansas farmers deal with insect pests. Snow led no expeditions from 1885 to 1889, but continued adding teaching duties until he was physically and mentally exhausted (Hyder 1953:143). If Snow’s 1884 expedition concluded as

such expeditions became low priority, there may have been adverse consequences for specimen management and labeling.

One remaining puzzle is *Poanes zabulon*, which Snow (1883) reported from his 1882 expedition (see

TABLE 4B. Butterflies attributable to Snow's 1884 expedition to Little Walnut Creek, but not reported by Snow (1885).

Taxon	Number of SEM specimens	Importance
<i>Erynnis meridianus</i> Bell, 1927	1	1st NM specimen
<i>Erynnis afranius</i> (Lintner, 1878)	1	
<i>Poanes taxiles</i> (W. H. Edwards, 1881)	1	
<i>Euphyes vestris</i> (Boisduval, 1852)	1	
<i>Amblyscirtes nereus</i> (W. H. Edwards, 1876)	1	1st NM specimen
<i>Eurema mexicana</i> (Boisduval, 1836)	1	
<i>Eurema salome</i> (C. and R. Felder, 1861)	1	1st NM specimen
<i>Eurema nicippe</i> (Cramer, 1779)	1	
<i>Plebejus lupini</i> (Boisduval, 1869)	2	1st NM specimens
<i>Thessalia theona</i> (Ménétriés, 1855) ssp. <i>thekla</i> (W. H. Edwards, 1870)	1	1st NM specimen
<i>Danaus gilippus</i> (Cramer, 1775)	1	1st NM specimen

<sup>1</sup> SEM = Snow Entomological Museum at the University of Kansas.



TABLE 4C. Butterflies collected by the Dyche party of Snow's 1884 expedition, but not reported by Snow (1885).

Taxon	Number of SEM <sup>1</sup> specimens	Importance
<i>Polites origenes</i> (Fabricius, 1793)	2	1st NM specimens
<i>Colias scudderi</i> (Reakirt, 1865)	1	1st NM specimen
<i>Erebia epipsodea</i> (Butler, 1868)	2	
<i>Oeneis chryxus</i> (Doubleday and Hewitson, 1849)	1	
<i>Oeneis uhleri</i> (Reakirt, 1866)	1	1st NM specimen

<sup>1</sup> SEM = Snow Entomological Museum at the University of Kansas.

Table 3). In 1978 Toliver located a specimen in the SEM and found it correctly determined, but its “New Mexico. F. H. Snow.” label links it to the 1884 expedition. More worrisome, however, is that *P. zabulon* does not occur west of the Great Plains (e.g., Ferris & Brown 1980:104, Scott 1986:452). *Poanes zabulon* breeds in the vicinity of KU and the SEM has many specimens of local provenance. Snow’s New Mexico specimen likely is mislabeled and the report in error; this may be the exception that shows what a careful scientist Snow was.

1894: Hop Canyon, Magdalena Mountains

After a 10-year absence from New Mexico, Snow returned to the Magdalena Mountains in early August 1894 with his son Frank, Ermine Case, Hugo Kahl and an unnamed student (Hyder 1953:280). They made camp in Hop Canyon, which is on the northwest flank of the Magdalena Mountains and descends through the town of Magdalena (Fig. 1). Snow’s camp may have been near the then-active lead mining camp of Kelly, about 30 air miles southwest of Socorro and 10 air miles west of his Water Canyon camp of 1881, and the terminus of the local railroad at that time.

Compared to that abbreviated effort 13 years earlier, this expedition went more smoothly. A fragment of a letter from Hop Canyon, dated 3 August 1894, was transcribed by one of Snow’s daughters many years later: “I think I was never so completely cut off from the world as here in this beautiful canyon . . . We have had no interruption of our successful entomological campaign except on Sunday and today. The latter interruption was in consequence of a great storm which came upon us last night . . . The dry bed of the canyon became an immense torrent in five minutes’ time and we were somewhat afraid that the flood

TABLE 5. Butterflies collected during Snow’s 1894 expedition to Hop Canyon, Magdalena Mountains, Socorro County, New Mexico.

Taxon	Number of SEM <sup>1</sup> specimens	Importance
<i>Erynnis pacuvius</i> (Lintner)	1	
<i>Celastrina ladon</i> (Cramer, 1780)	2	
<i>Lycaeides melissa</i> (W. H. Edwards, 1873)	1	
<i>Apodemia mormo</i> (C. and R. Felder, 1859) <i>spp. mejicana</i> (Behr, 1865)	1	1st NM specimen
<i>Speyeria hesperis</i> (W. H. Edwards, 1864) <i>spp. dorothea</i> Moeck, 1947	1	1st NM specimen
<i>Polygonia gracilis</i> (Grote and Robinson, 1867) <i>spp. zephyrus</i> (W. H. Edwards, 1870)	1	
<i>Nymphalis milberti</i> (Godart, 1819)	2	
<i>Vanessa virginiensis</i> (Drury, 1773)	1	

<sup>1</sup> SEM = Snow Entomological Museum at the University of Kansas.

would reach our tents, but we were high enough up to avoid that catastrophe . . . I have never had so efficient a team for collection of insects. Will and Mr. Kahl take first place and the rest of us are not far behind. We have averaged about 500 pinned insects per day . . .”

This expedition occurred while Snow was preoccupied as UK Chancellor and did not publish expedition results. Later, Snow (1907) published a comprehensive list of the Coleoptera collected on all six New Mexico expeditions including this one, but no 1894 Lepidoptera have been published previously.

The SEM contains nine examples of eight species from this expedition (Table 5). Most specimens have a typeset label stating “Magdalena Mts. N. M. Aug. ’94. Snow.” Others are labeled with “Magdalena, New Mexico.” Neither label specifies elevation, but Magdalena is at 6600 feet and Kelly is at 7400 feet. Snow’s practice in previous years suggests that locality labels are best interpreted as general descriptions of the area collected. Habitat associations suggest that Snow ventured to about 8000 feet elevation.

A few 1894 specimens are known from other institutional collections. A single specimen of *Mitoura grynea siva* (W. H. Edwards) was found by the senior author during review of collections at the NMNH ca. 1985. The name of Snow’s expedition assistant, H. Kahl, appears on labels of two Carnegie Museum



(CM) specimens of *Mestra amymone* (Ménétriés) from the "Magdalena Mts. N. M. Aug. '94. Snow." (Toliver et al. 1994:387).

#### DISCUSSION

Westward extension of the railroad opened the door for Snow's New Mexico expeditions. Snow was among the first entomologists to take advantage of 1000 miles of new track that penetrated and traversed New Mexico between 1879 and 1881 (Myrick 1990). With free passes donated by the Atchison, Topeka and Santa Fe Railroad (Hyder 1953:153), Snow probed the limits of railroad transportation in New Mexico in 1880, 1881, 1884 and 1894.

At the forefront of butterfly discovery in the American Southwest, Snow succeeded in finding butterflies new to science. *Lycaena cupreus snowi* (W. H. Edwards) and *Paratrytone snowi* (W. H. Edwards) were named in his honor after he discovered them in Colorado in the late 1870s (Snow 1879, 1881a). He collected examples of several species in New Mexico before they were formally described but, despite sending specimens to prominent scientists, most of Snow's New Mexico material was not used to describe new species. Only *Hesperia viridis* was described based on specimens collected by Snow in New Mexico (Edwards 1883). He also collected several taxa concurrent with, or shortly after, publication of formal descriptions.

Most of Snow's extant New Mexico butterfly specimens were located in the SEM, whose modest holdings of North American butterflies made the search for 80 Snow specimens reasonably profitable. In contrast, the few isolated specimens known from other institutional collections were encountered largely by accident. Collections at the NMNH, CM and AMNH are much larger and the numbers of Snow butterflies much smaller. The NMNH has records of receiving many of Snow's Orthoptera, but no such records for butterflies (Marc Epstein, pers. com., February 2002).

Workers in beetles and moths may find treasures among Snow's material. In his New Mexico expedition reports, Snow's lists of beetles and moths dwarfed those of butterflies. His role in the discovery and description of *Daritis howardi* (Hy. Edwards) (Arctiidae: Pericopinae) was documented elsewhere (Cary 2002). Snow collected beetles and moths at more places than he did butterflies, including Albuquerque and Socorro (Snow 1883, 1907). Rather than sit idle during evening stopovers in those towns, it would have been characteristic of Snow to find city lights or build large fires around which to collect beetles and moths all night. Some butterfly specimens eventually may turn up from these locations.

Snow's collections were the first substantive effort to document New Mexico butterflies. He recorded approximately 90 species—still the largest single contribution to knowledge of the New Mexico fauna. Some of these probably were collected in New Mexico previously, but most earlier reports lack meaningful documentation and, except for a few types, are anecdotal and lack scientific value. Snow set a new standard by publishing his results and describing collectors, identifiers, locations and dates. He left dozens of specimens pinned with labels containing information still useful today. Subsequent New Mexico butterfly study would be based on this foundation.

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## DISTRIBUTION OF THE DIANA FRITILLARY, *SPEYERIA DIANA* (NYMPHALIDAE) IN ARKANSAS, WITH NOTES ON NECTAR PLANT AND HABITAT PREFERENCE

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**ABSTRACT.** Investigation of the distribution, preferred nectar plants, and habitat associations of Diana Fritillary, *Speyeria diana*, Cramer in Arkansas was undertaken. Arkansas populations form a disjunct group separate from larger populations of this species in the Appalachian Mountains. Researchers have suggested that *S. diana* has declined over much of its range, including the Ozark and Ouachita Mountains of Arkansas, so that only a few populations are currently known in this area. Previous surveys found this butterfly in only nine Arkansas counties. We observed populations of this butterfly in 14 counties, 11 which were new county records. In addition, we confirmed populations in two counties where the butterfly had not been recorded in over 20 years. Observations made during this study combined with previous survey work indicate that this species is distributed throughout the Ozark and Ouachita mountains in Arkansas, occupying 22 counties. Individuals were found to occupy two types of habitat; prairie and wetland, which appeared to contain specific nectar plants that *S. diana* prefers. We suggest that the loss of these habitats and associated nectar plants has been the primary cause of the butterfly's decline, but with proper management and protection of these habitats, the species may be increasing. Therefore, *S. diana* does not appear to be in immediate risk of extirpation in Arkansas although monitoring of existing populations is warranted.

**Additional key words:** survey, Ozark Mountain, Ouachita Mountain, prairie, wetlands, habitat loss.

Several North American fritillary butterflies have become endangered in the last century, often because of habitat alteration (Hammond & McCorkle 1983, Hammond 1995). One species of concern has been the Diana Fritillary, *Speyeria diana* Cramer (Nymphalidae). The historical range of *S. diana* extended from the Chesapeake Bay region, across the southern Appalachians, through Tennessee, Kentucky, and into northern Georgia, Alabama, and Mississippi. Possible disjunct populations existed in Arkansas and southern Missouri, ending at the deciduous forest/prairie ecotone in eastern Oklahoma and Kansas (Hovanitz 1963, Carlton & Nobles 1996). Several authors have suggested a great decline throughout much of the range of *S. diana* (Clark 1951, Shull 1987, Howe 1975) so that currently, populations exist only in the Appalachian Mountains and the Interior Highlands of the Ozark Plateau and Ouachita Mountains covering Arkansas, Missouri, and Oklahoma (Carlton & Nobles 1996). Survey work conducted by Carlton and Nobles in 1996 found *S. diana* at several Ozark and Ouachita localities covering nine counties. The authors suggested that the populations were small and isolated and therefore at high risk for extinction.

*Speyeria diana* emerges in late spring, mating occurs in early summer, after which males disappear and presumably die. Females are seldom seen during the rest of the summer months, but become active again in mid-autumn to oviposit. Eggs are deposited on the ground, the larvae hatch and overwinter as first stadium larvae. In early Spring, the larvae become active again, feed on various species of violet (*Viola* spp. L.), and pupate by mid-spring. There is one generation per year (Howe 1975).

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To document further the range of *S. diana* in the western portion of its range, we conducted surveys throughout Arkansas, focusing on areas where the butterflies were not observed in the Carlton and Nobles (1996) survey. We also searched areas that had historical records that have not been confirmed in recent years. Observations on the behavior of each butterfly observed were made, primarily nectar plant preferences to determine possible habitat requirements.

### MATERIALS AND METHODS

During the summers of 1997–1999 we performed extensive surveys of Arkansas habitats for *S. diana*. A total of 23 counties were surveyed by the authors near the known range of the butterfly. Additional records were provided by The Nature Conservancy, the National Forest Service, and other scientists in Arkansas. For each butterfly observed, we recorded its sex, noted its behavior when sighted, and the associated habitat. All observations were performed during June, July, and early August when adult butterflies are active. We began by focussing on areas with known (although old) records of *S. diana*, and then surveyed surrounding counties that did not have published records of this species.

Surveys were performed on public lands by walking trails and driving back roads. In particular, areas that contained significant concentrations of nectar plants were searched carefully for *S. diana*. In areas of private land, we drove slowly along roadsides searching for possible nectar plants. We searched a variety of available habitats including mature forest, wetlands, prairies, and human-disturbed areas. A total of 375 man-hours were spent searching in the field.



## RESULTS

Individuals of *Speyeria diana* were observed each year of the study (1997–1999) at numerous sites across Arkansas. Records from observers other than the authors were also added in 2000–2001. Butterflies were found in 14 different Arkansas counties, 11 of which represent new county records. Two of these counties, Conway and Faulkner, have not had sightings of this species in over 20 years. Below are the initial observations from each county (i.e., first time we observed specimens). Observations were made by the authors unless otherwise indicated.

**Conway Co.;** Petit Jean St. Park, West end of Bailey Lake, 10 July 1998, one female nectaring on buttonbush (*Cephalanthus occidentalis* L.); **Faulkner Co.;** Camp Robinson National Guard Base, along Cemetery Road, forested wetland, 7 July 1997, four males and one female nectaring on *C. occidentalis*; **Pulaski Co.;** Camp Robinson National Guard Base, along Clinton Rd., south of Clifton Mountain, forested wetland, 7 July 1997, one male nectaring on *C. occidentalis*; **Yell Co.;** Mt. Nebo St. Park, Fern Lake near Summit Park Trail, 10 July 1998, one male nectaring on *C. occidentalis*; **Johnson Co.;** Ozark Highlands Trail in Hurricane Creek Wilderness, open glade, 17 July 1997, one male nectaring on Purple Coneflower (*Echinacea purpurea* Moench), P. Kilgore; **Logan Co.;** Mt Magazine, one-half kilometer west of Signal Hill summit, open glade, 25 June 1997, 5 males and 1 female nectaring on *E. purpurea*, MDM and P. Kilgore; **Howard Co.;** Stone Road Glade Natural Area, June 1998, 3 males nectaring on Pale Purple Coneflower (*Echinacea pallida* Britton) and 1 female nectaring on Compass Plant (*Silphium laciniatum* L.), Douglas Zollner; **Hempstead Co.;** Grandview Prairie Wildlife Management Area, numerous males and females sighted during summer of 1998 and 1999, Douglas Zollner; **Clark Co.;** Terre Noire Natural Area, June 1997, 1 male nectaring on *E. pallida*, and July 1999, 3 females nectaring on *S. laciniatum*, Douglas Zollner; **Jefferson Co.;** Pine Bluff Arenal, June 1999, 2 males and 1 female nectaring on *E. pallida*, Douglas Zollner; **Saline Co.;** Dry Lost Creek Preserve, late May 1999, 3 males nectaring on Arkansas calamint (*Satureia arkansana* Nutt.), and June 1999, 1 female nectaring on slender mountain mint (*Pycnanthemum albescens* Torr.), Douglas Zollner; **Polk Co.;** Ouachita National Forest, Forest Service Rd 1401, about 10 miles south of Mena, AR, 1 July 2000, 1 female, Craig Rudolph; **Garland Co.;** Ouachita National Forest, Mazarn Creek and Forest Service Rd. 829, 2 June 2000, 2 males, Craig Rudolph; **Pike Co.;** Ouachita Na-

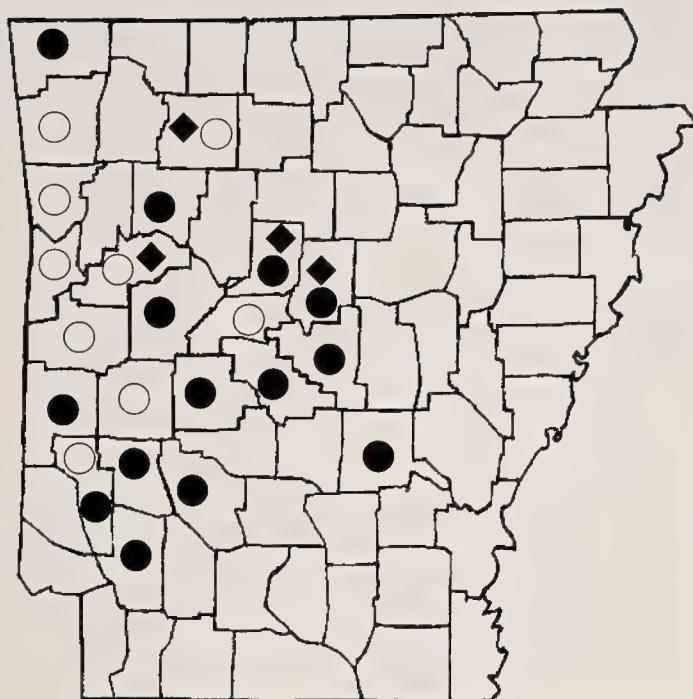


FIG. 1. Range map of the Diana Fritillary (*Speyeria diana*) in Arkansas based on surveys from this study and previous records. Diamonds = old observations from published literature; open circles = Carlton and Nobles (1996) observations, Closed circles = observations from this study.

tional Forest, Highway 84, 4.2 miles west of Salem, AR, 7 June 2001, 1 male, Craig Rudolph; **Benton Co.;** Wedington Natural Area, 24 July 2002, 1 male, Lori Spencer. These records indicate populations exist throughout much of the western one-half of Arkansas, primarily in the mountainous and foothill regions of the state. (Fig. 1). Our surveys in the eastern portion of the state failed to record any individuals except for the Jefferson County record provided by the Nature Conservancy.

Populations of *S. diana* were found in two types of habitats, prairie and wetland. In southwest Arkansas, many butterflies were found in prairie habitat. Individuals in four sites (Stone Road Glade, Grandview Prairie, Terre Noire, and Dry Lost Creek) were found in the year after prescribed burns. In the Ozark and Ouachita mountains, *S. diana* was associated with small natural prairie openings (e.g., Magazine Mountain, Hurricane Creek Wilderness) while those in central Arkansas were found in wetland areas (e.g., swamps in Camp Robinson, Mt. Nebo, and along Baily Lake).

During our field observations we also recorded the activity of the butterflies. The vast majority of individuals were nectaring, however, butterflies were often observed on only a few species, with Buttonbush (*C. occidentalis*) and cone flowers (*Echinacea* spp.) the most commonly utilized plants (Table 1). Females



TABLE 1. Percentage of individual male and female *S. diana* observed on various nectar plants. N = number of individuals observed.

Nectar Plant	Percent Males (N = 46)	Percent Females (N = 23)
<i>Cephalanthus occidentalis</i>	56.5	26.1
<i>Echinacea purpurea</i>	21.7	8.1
<i>Echinacea pallida</i>	13.0	21.7
<i>Pycnanthemum albescens</i>	6.5	4.3
<i>Rubus</i> sp.	2.2	0.0
<i>Silphium laciniatum</i>	0.0	34.8
<i>Satureja arkansana</i>	0.0	4.3

were frequently observed on Compass Plant (*S. laciniatum*) on prairie sites. Several other plant species were present at our sites and used by other species of butterfly. Although there were more males than females observed, this may not indicate an actual biased sex ratio as males have bright coloration and are therefore easier to detect in the field. The habitat preference (wetland or prairie) seemed to be determined by the presence of preferred nectar plants, and not the habitat per se.

#### DISCUSSION

Our results indicate that the Diana Fritillary is more widespread than previously thought. Based on our newly constructed range map (Fig. 1) and habitat observations, *S. diana* appears to range throughout the Ouachita and Ozark Mountains of Arkansas, where there is suitable wetland and/or prairie habitat with preferred nectar plants. We also performed extensive surveys throughout eastern Arkansas, but were unable to locate any individuals, even though preferred nectar plants utilized in other areas were present.

It has been suggested that clearing of old-growth forest in the eastern United States has been primarily responsible for the decline of *S. diana*, due to larval host plant decline (Clark 1951, Howe 1975, Hammond & McCorkle 1983, Shull 1987). However, based on our observations, we find this explanation wanting. *Speyeria diana* larvae feed on several species of violets (*Viola* spp.), which are extremely common in Arkansas. Many of our observations and observations by Carlton and Nobles (1996) were in at least moderately disturbed habitat. The largest number of sightings in this study were in the Camp Robinson National Guard Base and surrounding areas, habitat that is mostly second growth forest and pasture, and is frequently burned due to military firing exercises. Butterflies were also observed after prescribed burning at several sites, further indicating that this type of disturbance is not the primary cause of the butterfly's decline. Reports from the National Forest Service sites

in western Arkansas indicate that butterflies become more common after prescribed burns are undertaken for Red Cockaded Woodpecker habitat (C. Rudolph, pers. com.). We believe it is more likely that loss of wetland and prairie habitat and the associated loss of preferred nectar plants is the reason for this butterfly's decline. Throughout the United States, large areas of wetland have been drained (Weller 1981, Tiner 1984) and most prairie habitat has been lost to farmland conversion or has undergone succession to forest because of fire suppression (Humphrey & Mehrhoff 1958, Bock & Bock 1995).

It should be noted that we did not search for larvae, which may prefer quite different habitats compared to adults. The larval host plants (*Viola* spp.) are most common in moist forest. In addition, many butterflies (especially females) appear to prefer deep, shady forests during times of strong sunlight (P. C. Hammond, pers. com.). Therefore, high quality forest in the vicinity of quality nectar plants (i.e., mixture of forested and open habitats) may be important for this species.

The Diana Fritillary has an unusually long adult life span, especially females, which are observed from June to October (up to 5 months). Many long-lived butterflies require high quality nectar sources (e.g., *Heliconius*, Gilbert 1972), and we suggest this is the case for *S. diana*. The loss of prairie and wetland habitats, and subsequent loss of nectar plants may have contributed to the decline of this species throughout much of its range.

While our survey indicates *S. diana* is more widespread than previously thought, it is still a relatively rare butterfly. There are now 22 known populations in Arkansas, most of which are on public land. We suspect that further survey work will discover additional populations. It is unclear if the species' population is increasing or has simply been overlooked in the past. The latter may be the case, as males resemble the Great Spangled Fritillary, *Speyeria cybele* Fabricius and females are rather secretive and resemble several other species, especially the Red-Spotted Purple, *Basilarchia astyanax* Drury. It is also possible that changes in habitat management are benefiting this species, as prescribed burning has become more common and wetlands are better protected. While *S. diana* does not appear in immediate danger of extinction in the Ozark and Ouachita areas, future monitoring efforts will be required to determine if existing populations are stable.

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EVIDENCE FOR THE NEGATIVE EFFECTS OF *Bt*  
(*BACILLUS THURINGIENSIS* VAR. *KURSTAKI*) ON A NON-TARGET  
BUTTERFLY COMMUNITY IN WESTERN OREGON, USA

**Additional key words:** *Bt*, species richness, butterfly abundance, diversity.

*Bacillus thuringiensis* var. *kurstaki* (*Bt*) is a gram-positive bacterium commonly occurring in soil (Martin & Travers 1989) and plant leaves (Smith & Couche 1991) with known pathogenic properties for butterfly and moth larvae. Generally, when *Bacillus* bacteria experience starvation or stressful conditions they form a spore, an inactive resting stage (Brock 2000), that is lethal to most Lepidoptera larvae when ingested. Consumption of *Bt* spores by butterfly and moth larvae activates bacterial Cry proteins (toxins) by proteolysis from the larva's gut enzymes (Tojo & Aizawa 1983). Once the bacteria's toxins are activated by proteolysis, the proteins bind to the apical brush border gut microvillae cells (Hofmann et al. 1988) and form an ion channel that disrupts solute concentrations within the cell. Ion pore size increases with increasing gut alkalinity resulting in decreasing solute control with larger pore sizes (Schwartz et al. 1993). The lack of cellular solute control causes water to enter the cell and lyses cells having sufficient numbers of *Bt* ion pores. Presumably, the loss or dysfunction of gut epithelial cells causes mortality of infected Lepidoptera species.

*B. thuringiensis* var. *kurstaki* is commonly employed as a biological control agent for lepidopteran pests on agricultural plant species, but other *Bt* variants are pathogenic to mosquito and black flies (Hershey et al. 1998), coleopterans, hymenopterans, and orthopterans (Schnepf et al. 1998). *Bt* is suspected of causing abnormally high larval mortality rates in non-target butterfly species like Monarchs, *Danaus plexippus* L. (Danaiidae) (Losey et al. 1999), various swallowtail species (*Papilio*) (Johnson et al. 1995, Peacock et al. 1998), and a host of other butterfly and moth species (Wagner et al. 1996, Peacock et al. 1998, Whaley et al. 1998). Miller (1990, 1992) observed a decrease in larval density, diversity, and species richness of lepidopteran guilds feeding on *Quercus garryana* Douglas (Fagaceae) and *Ceanothus velutinus* Douglas (Rhamnaceae) following aerial *Bt* application. Bio-engineering of genes encoding the *Bt* Cry toxins into corn plants and the dispersal of transgenic pollen into hedgerows bordering cornfields is linked to increased larval mortality of native butterfly species when pollen

coated leaves are consumed by larvae (Losey et al. 1999, Hansen Jesse & Obrycki 2000).

Elevated larval death rates due to *Bt* not only impacts butterfly and moth populations, but is also capable of altering higher trophic level interactions with insectivorous species. *Sorex cinereus* (masked shrew) males migrated out of a *Bt* treatment area and all shrews altered their prey selection from Lepidoptera larvae to less preferred hemipterans and hymenopterans after a *Bt* spray reduced larval abundance (Bellocq et al. 1992). Parent birds fed their nestlings fewer caterpillars in *Bt* treated areas (Gaddis & Corkran 1986, Rodenhouse & Holmes 1992, Nagy & Smith 1997) or increased their foraging times compared to birds nesting in untreated areas (Holmes 1998). Although a decrease in Lepidoptera larval abundance did not appear to effect the average nestling weight, survivorship through fledging, or egg size in birds from a *Bt* treated area (Gaddis & Corkran 1986, Rodenhouse & Holmes 1992, Nagy & Smith 1997), lower fat reserves were detected from birds in a Dimilin (a lepidopteran larvicide with impacts similar to *Bt*) treated forest (Whitmore et al. 1993).

Lepidoptera larvae, particularly early instars, experience the acute effects of *Bt* toxins and therefore have received the bulk of the attention from researchers. Conversely, adult non-target Lepidoptera populations in *Bt* treated sites have received very little attention, possibly due to methodological problems accompanying the sampling of adult abundance over potentially large spray areas. However, Whaley et al. (1995) noted substantial reductions in adult population sizes for *Incisalia fotis* Strecker (Lycaenidae) and *Neominois ridingsii* Edwards (Satyridae) in Utah following a *Bt* spray.

Increased larval mortality from *Bt* use should result in the reduction of adult non-target Lepidoptera populations. The butterfly community should respond to eradication dosages of *Bt* by displaying a reduction in species richness, diversity, and adult abundance in the years following the spray. Furthermore, because *Bt* will likely elevate mortality rates of all butterfly species in the community, reductions in species abundance should be synchronized among species. I monitored a



relatively small *Bt* spray, approximately 32 ha, that occurred in the spring of 1997 in western Oregon to assess the effects of *Bt* on the adult non-target butterfly community.

**Study site description.** Schwarz Park, situated downstream of Dorena Reservoir, Lane Co. Oregon, is a 32.4 ha (80 acres) *Bt* treatment area for a local gypsy moth infestation. The Schwarz Park *Bt* spray site contains three different habitats that presumably received equal dosage treatments, a “groomed,” “prairie,” and “spillway” habitat. The groomed habitat consists of 14.2 ha (35 acres) of lawn and *Pseudotsuga menziesii* (Mirbel) Franco (Pinaceae), Douglas-fir, forest maintained for camping and recreational use. The spillway habitat is 8.1 ha (20 acres) of young riparian forest interspersed with native upland prairie and cliff face. An area of 10.1 ha (25 acres) of degraded upland prairie with a narrow swath (0.8 ha) of riparian habitat and young Douglas-fir forest compose the remaining prairie habitat. The *Bt* treatment area is bounded by reservoir water to the east, and sporadically clearcut Douglas-fir forests to the north, west, and south. Excluding the nearby residential developments and an U.S. Forest Service tree genetics research site, Schwarz Park is the only area within 5 km that is suitable upland prairie butterfly habitat. On 30 April, 8 May, and 20 May of 1997, three aerial applications of Foray 48B (*Bt*) at 24 B.I.U.s were administered by helicopter at least 15 m (50 feet) above the tree canopy over the Schwarz Park spray area (Bai & Johnson 1997).

**Adult surveys and analysis.** The 32.4 ha spray area was subdivided into three habitats (spillway, prairie, and groomed) that were systematically surveyed for adult butterflies once every three to four weeks beginning in late April and ending in early June from 1997 through 2000. Target flight periods for sampling were late April, mid May, and late May/early June that correspond with the spring butterfly community flight period. Temporal separation of adult sampling dates by approximately two weeks ensured that most adult butterflies would not be counted twice because the butterflies from the first survey period would likely be dead by the second survey period. In most instances, adult butterflies were accounted for and identified without capturing or disturbance. By avoiding injury and death of the adult population through surveyor disruption, butterfly reproductive capability was not diminished through capturing or disturbance while ovipositing. Survey days were restricted to climate conditions that favored the flight of adult butterflies while maintaining the seasonal timing of the initial survey periods from the original spray

TABLE 1. Butterfly diversity for the Schwarz Park spray area. \* = significant difference in diversity compared to the spray year, 1997.

Year	Shannon Diversity ( $H'$ )	Year Comparison (modified $t$ -test) of $H'$
1997	0.9840	
1998	0.7408	*1997 $\times$ 1998 $t = 2.77$ $P < 0.01$
1999	0.5497	*1997 $\times$ 1999 $t = 4.92$ $P < 0.0001$
2000	0.8607	1997 $\times$ 2000 $t = 1.59$ $P > 0.05$

year. Adult surveys were performed from 1030 h–1630 h and occurred on days when temperatures were near or above 21°C (70°F) under sunny conditions. Butterfly binomial nomenclature was synonymous with the locally accepted names published by Hinchliff (1994).

Adult surveys were conducted systematically by walking transects approximately 5 m apart progressing from one end of a subarea, defined by physical barriers, to the other end. Subareas, nested inside the three habitats, were 0.8–2.0 ha and delineated by physical boundaries so survey replication within and between sampling years was consistent. If large numbers of butterflies occupied a subarea (only occurred once in 1997), all butterflies within the site were captured in an aerial insect net and held until the butterflies in the subarea were accounted for, identified to species, and then released. Once all transects in a subarea were surveyed, butterfly data gathering was finished for that particular subarea and then began anew in the next subarea.

The spray year, 1997, was used as baseline data for yearly pairwise comparisons because it was assumed that the majority of the adult spring butterfly species would have overwintered as a pupae or late instar larvae, and would thus be unaffected by the timing of the *Bt* spray. Butterfly abundance was estimated by dividing the total number of butterflies counted per survey by the spray area (32.4 ha). Butterfly diversity was calculated for each year using the Shannon Diversity Index (Magurran 1988). Yearly diversity measurements were compared for significant pairwise differences between the spray year and the three postspray years using a modified  $t$ -test described in Zar (1996).

**Community response.** Diversity was significantly lower in the two postspray years, 1998 ( $P < 0.01$ ) and 1999 ( $P < 0.0001$ ), when compared pairwise to the spray year 1997 (Table 1). The decline in diversity of the non-target butterfly community immediately following the spray suggests that the *Bt* application negatively impacted the local butterfly community. Butterfly species richness throughout the four-year study



period was also substantially lower in the two years following the *Bt* spray (Appendix). In 1997 there were 22 species detected in the spray area, but in the two following postspray years species richness had dropped to only eight species (Appendix). In the year 2000, three years following the initial spray, species richness was 19, a level similar to that measured in the spray year (Appendix). Furthermore, butterfly density was also substantially lower in the two postspray years compared to the spray year. In 1997 there were 5.49 individuals/ha, while in 1998 and 1999, there were only 1.27 and 2.68 individuals/ha respectively. However, there were more butterflies per hectare in 2000, 8.18 individuals/ha, than there were in the spray year, suggesting that the assumption of a no treatment effect on the adult butterfly community during the spray year was violated with some species.

Butterfly diversity, species richness, and density all showed similar reductions in numbers following the year following the *Bt* spray, but the lack of a suitable control area to statistically account for stochastic effects on an untreated butterfly community is a drawback to this study. Despite a lack of a suitable control area, fair numbers of *Mitoura grynea* (6 individuals), *Boloria epithore chermocki* (8 individuals), *Euphydryas chalcedona colon* (18 individuals), *Everes comyntas* (10 individuals), *Parnassius clodius claudianus* (4 individuals), and *Papilio rutulus* (5 individuals), were detected just outside the spray boundary in 1998 during one sampling day. However, no individuals of the same butterfly species were found within the *Bt* treatment area (Appendix), suggesting the detrimental effects of *Bt* on the local butterfly populations.

Further evidence for the effects of *Bt* on adult populations are demonstrated by comparing the yearly population size and life history of the two dominant butterfly species, *Ceononympha tullia eunomia* and *Glaucopsyche lygdamus columbia*. *Ceononympha t. eunomia* was in the larval life stage during the *Bt* spray, so the small adult population in the spray year was likely the effect of the *Bt* treatment. The abundance of *C. t. eunomia* was lowest in the spray year and steadily increased with time following the *Bt* spray (Appendix). Comparing *C. t. eunomia* to another dominant species, *Glaucopsyche lygdamus columbia*, that was in the pupal stage when the spray occurred (adults would not be affected in the spray year), a different trend in adult abundance occurred. *Glaucopsyche l. columbia* adult populations were high in the spray year and low the two following years (Appendix), indicating that the *Bt* treatment did affect the competitively dominant species of the butterfly community and likely the competitively inferior species as well.

The data from the *Bt* spray (Appendix) evince that an overall depression in butterfly abundance occurred in the years following the spray. Moreover, the decreasing trend among the majority of the butterfly species was synchronized, implying that a large scale disturbance event affected the community. Outside of seasonality, synchronized patterns in species abundance are not expected to occur unless some catastrophic ecological event affects the entire community. Butterfly community data from a five year study in Ecuador demonstrate the asynchronous nature of the component species in a butterfly community under natural conditions (DeVries & Walla 2001). Pollard (1984) collected butterfly species abundance data for numerous sites throughout England for seven years, a Temperate Zone with a butterfly community similar to western Oregon, and the butterfly species did not all follow the same pattern of relative abundance increases and declines between years. The only known factor that had the potential to cause a community wide concurrent decrease in species abundance at Schwarz Park was the *Bt* spray.

Miller (1990, 1992), Peacock et al. (1998), and Whalley et al. (1998) predicted local species extinction of non-target Lepidoptera in response to repeated *Bt* application events. Locally distributed, monophagous, and rare Lepidoptera species are the ones most likely to experience a resultant *Bt* induced extinction because they occupy narrow ecological niches. It appears that a localized extinction of three non-target butterfly species transpired within Schwarz Park following the spray. *Mitoura grynea*, *Parnassius clodius claudianus*, and *Phyciodes p. pratensis* were found in 1997, but were not detected inside Schwarz Park the three years following the spray (Appendix). Larvae of *M. grynea* use *Calocedrus deccurens* (Torr.) Florin. (Cupressaceae), *P. clodius claudianus* uses *Dicentra formosa* (Andr.) Walp. (Papaveraceae), and *P. pratensis* uses *Aster hallii* (Gray) Cronq. (Asteraceae) as their sole larval host plants at the study site, which are locally restricted within the treatment area. Two migratory butterfly species, *Danaus plexippus* and *Vanessa cardui* (Scott 1986), were found in 1997 but have not been seen since, perhaps indicating that they too were extirpated from the treatment area. However, it is not known if there were local populations of these species in Schwarz Park before the spray or the individuals were observed migrating through the area. Considering the relatively small size of the spray area (32.4 ha), local butterfly extinction should not transpire because there is ample edge habitat for recolonization. However, the isolated nature of the spray site and the relative blanketing of butterfly habitat with *Bt* spores suggests how



even common species can be at risk of local extinction when they are subject to pest control measures.

In the case of Schwarz Park, the spray area was relatively small, but non-target Lepidoptera populations in larger spray areas may not recover as quickly as the Schwarz Park area. Historical *Bt* sprays in western Oregon have been large, a 120,000 ha block was repeatedly sprayed in 1985, 1986, and 1987 (Johnson et al. 1989). With increasing evidence for the negative consequences of *Bt* on non-target Lepidoptera communities and the species that depend on Lepidoptera for food, the ecological impacts associated with broad-scale use of *Bt* for pest control should be questioned. Other alternatives that are pest species specific are the best option for minimizing the mortality and large-scale disruption of native Lepidoptera communities in pest eradication areas.

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APPENDIX. Adult butterfly data for the Schwarz Park spray site from 1997–2000. “\*\*” = migratory species.

Butterfly Species	Diapause Life Stage	1997	1998	1999	2000
<b>Hesperiidae</b>	Larvae	5	0	0	3
<i>Erynnis propertius</i> (Scudder & Burgess)					
<i>Pyrgus communis</i> (Grote)	Multivoltine	1	0	0	6
<i>Ochlodes s. sylvanoides</i> (Boisduval)	Eggs or 1st instar	0	0	0	1
<i>Amblyscirtes vialis</i> (W. H. Edwards)	Larvae	0	0	0	1
<b>Papilionidae</b>					
<i>Parnassius clodius claudianus</i> Stichel	Eggs	2	0	0	0
<i>Papilio rutulus</i> (Lucas)	Pupae	1	0	0	9
<i>Papilio eurymedon</i> (Lucas)	Pupae	1	0	0	6
<b>Pieridae</b>					
<i>Pieris napi marginalis</i> Scudder	Pupae	1	0	0	3
<i>Pieris rapae</i> Linnaeus	Multivoltine	0	0	0	1
<i>Anthocharis sara flora</i> Wright	Pupae	3	1	1	3
<i>Colias eurytheme</i> Boisduval	Multivoltine	0	2	0	0
<b>Lycaenidae</b>					
<i>Mitoura grynea</i> (Huber)	Pupae	5	0	0	0
<i>Strymon melinus setonia</i> McDunnough	Multivoltine	8	5	5	14
<i>Everes comyntas</i> (Godart)	Multivoltine	5	0	0	15
<i>Celastrina argiolus echo</i> (W. H. Edwards)	Pupae	13	4	4	12
<i>Plebejus acmon acmon</i> (dos Passos)	Multivoltine	0	0	1	0
<i>Glaucopsyche lygdamus columbia</i> (Skinner)	Pupae	97	16	55	108
<b>Nymphalidae</b>					
<i>Phyciodes mylitta mylitta</i> (W. H. Edwards)	Multivoltine	15	6	8	30
<i>Phyciodes p. pratensis</i> (Behr)	Pupae	1	0	0	0
<i>Boloria epithore chermocki</i> (Perkins & Perkins)	4th instar larvae	4	0	0	2
<i>Euphydryas chalcedona colon</i> (W. H. Edwards)	3rd or 4th instar larvae	2	0	0	1
<i>Polygonia satyrus</i> (W. H. Edwards)	Adult	1	0	2	1
<i>Nymphalis antiopa</i> (Linnaeus)	Adult	1	1	0	0
<i>Vanessa cardui</i> ** (Linnaeus)	Adult	1	1	0	0
<i>Vanessa atalanta rubria</i> ** (Fruhstorfer)	Adult	1	0	0	1
<b>Satyridae</b>					
<i>Coenonympha tullia eunomia</i> (Dornfeld)	3rd or 4th instar larvae	8	7	11	48
<b>Danaidae</b>					
<i>Danaus plexippus</i> ** (Linnaeus)	Adult	2	0	0	0



NOMENCLATURAL CORRECTNESS OF *PHYCIODES PRATENSIS* VS.  
*PHYCIODES PULCHELLUS* (NYMPHALIDAE)

**Additional key words:** nomenclature, *pulchella*.

Scott (1994) published an exhaustive analysis of *Phyciodes* species names, including the issue of whether *pulchella* (Boisduval, 1852) or *pratensis* (Behr, 1863) is the correct name in accordance with the rules of zoological nomenclature, for the widespread “Field Crescent” butterfly of western North America. Bird et al. (1995) adopted the use of *pulchella*, as did Emmel et al. (1998) who emended the spelling to *puchellus* to conform to the gender congruence provisions of the International Code for Zoological Nomenclature (International Commission on Zoological Nomenclature [ICZN] 1999). Other recent authors, such as Guppy and Shepard (2001), Layberry et al. (1998) and Opler (1999), used *pratensis*, with only Layberry et al. (1998) providing any reasons for taking this approach. This on-going disagreement regarding the usage of these two names needs further discussion, to establish nomenclatural stability.

Layberry et al. (1998) disagree with the use of *pulchella* because of two alleged shortcomings in the original description. One stated shortcoming is that the name “. . . lacked a description (required for all new species) . . .”. This alleged shortcoming is an incorrect summary of nomenclatural requirements. New names published prior to 1931 are in fact available on the basis of a description, a definition or an indication (ICZN 1999, Article 12). An indication denotes “the proposal of a new . . . species-group name in association with an illustration of the taxon being named, or with a bibliographic reference to such an illustration . . .” (ICZN 1999, Article 12.2.7). In naming *pulchella*, Boisduval (1852) provided a clear indication to two published illustrations that he considered to be *pulchella*. He cited “Drury, Ins. I. Pl. 21, f.5,6” which is a clear reference to two illustrations in Drury (1770). This, together with Boisduval having met the requirements of ICZN (1999) Article 11, establishes the availability of the name *pulchella* Boisduval, 1852.

Scott (1994) missed the simplicity of this conclusion, and instead concluded that the reference to the illustrations, combined with Drury’s statement that *pulchella* is not to be confused with *P. tharos* or *P. morphheus*, constitutes a description or definition. Whether this conclusion is correct (it is, at best, a very poor definition) is irrelevant, because the name *pulchella* is available through an indication, regardless of whether a description or definition is provided. It is also interesting to note that *P. tharos* Drury, 1773 was named through indication to the same figures in Drury

(1770). This situation gets even more interesting when one realises that Kirby (1837) also referenced the same figures in his description of *P. selenis*.

The second shortcoming stated by Layberry et al. (1998) was that *pulchella* “. . . was proposed by Boisduval to be applied to an illustration of *Phyciodes tharos* in Drury’s classical book (1773) . . .” and thus *pulchella* should be viewed as a junior synonym of *tharos*. While researching this issue, one colleague suggested that the type of *pulchella* is the figure in Drury and hence *pulchella* is an objective synonym of *tharos*. This cannot be. The International Code of Zoological Nomenclature (Article 72.5.6) sets out that the name bearing type is the specimen or specimens and not the illustration, although perhaps our colleague intended to suggest that the type was the specimen(s) on which Drury’s illustration was based. However, Boisduval only indicated that the specimen(s) illustrated by Drury (1770) represented his new species *pulchella*; he did not assert that the illustration was the “type” specimen to which he was applying the name. Boisduval did not specify a holotype, and the actual name bearing type of *pulchella* is a specimen in the United States National Museum. The specimen has been designated both as a lectotype and as a neotype (Scott 1994, Emmel et al. 1998). *Pulchella* can only be a subjective synonym of *tharos* for those people who might be inclined to view *pulchella* and *tharos* as being the same taxon. We are unaware of anyone who has suggested such a taxonomic interpretation. It is also irrelevant that the illustrations in Drury (1770) that were indicated in Boisduval’s description of *pulchella* are in fact illustrations of dark *tharos*, because the type specimen determines the application of a name and the actual identities of all other specimens or illustrations are irrelevant.

The name *pulchella* is therefore available in conformance with the International Code of Zoological Nomenclature. Furthermore, there is no question that the name-bearing type of *pulchella* is a different butterfly than the name-bearing type of *tharos*, so *pulchella* cannot be a synonym of *tharos* Drury, 1773. An author denying the correctness of *pulchella* must demonstrate a deficiency in the lectotype designation, followed by demonstration of a deficiency in the neotype designation, or they stand in non-compliance with the International Code of Zoological Nomenclature. Nothing has been published to upset the correctness of *pulchella* over *pratensis*. So the correct name for



this butterfly is *Phyciodes pulchellus* (Boisduval, 1852) by virtue of the provisions of the Code, including gender congruence.

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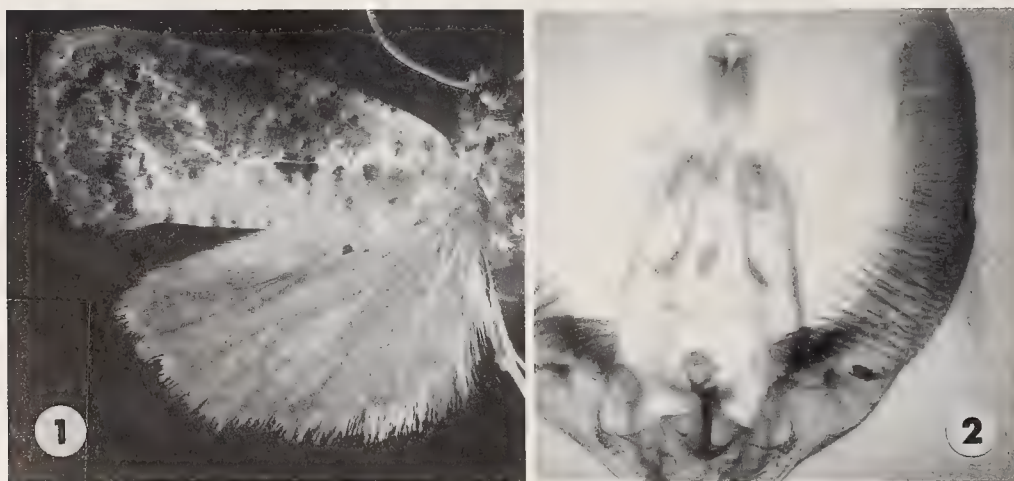
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#### *HEDYA SALICELLA* (L.), A PALAEARCTIC SPECIES, COLLECTED IN NORTH AMERICA (TORTRICIDAE)

**Additional key words:** immigrant, Olethreutinae, *Salix*, *Populus*.



FIGS. 1–2. *Hedyia salicella* male from Atchison Co., Missouri. 1. Wings. 2. Genitalia (genit. slide MS 97199).

*Hedyia salicella* (L.) is a trans-Palaearctic species whose larvae feed in spun shoots and folded leaves of *Salix* and *Populus* species (Salicaceae). The five North American specimens reported here were in three different collections, two public and one private. The distinctive forewing and genitalia of these specimens (Figs. 1, 2) match illustrations and adult sizes in Bentinck & Diakonoff (1968), Bradley et al. (1979), and other handbooks on Eurasian Olethreutinae. They

also match three pinned adults of *H. salicella* from England and Germany that we examined.

The American specimens were collected over a 30-yr period at scattered localities: 1956 in Ontario, 1975 in Massachusetts, and 1985 in Newfoundland and Missouri. Such a diffuse temporal-geographic pattern provides little specific information about introduction and spread beyond the general conclusion that *H. salicella* is an immigrant in North America.



The June–August adult recovery dates are similar to those reported in Eurasia (Bentinck & Diakonoff 1968, Bradley et al. 1979, Kuznetsov 1989), and suggests that *H. salicella* is bivoltine in North America. Details of wintering in Eurasia are unclear, but adult flight dates also suggest that the egg or partly grown larva is the wintering stage.

**Specimens examined.** North America: Vittoria, ON, 13–VIII-56, Freeman & Lewis, Canadian National Collection of Arthropods (CNC), Ottawa, ON; Cambridge, MA, 381 Walden St. at Concord Ave., 26–VI-75, R. Silberglied, at 15 w blacklight, male genit. slide WEM 911981, forewing length 9.0 mm, Museum of Comparative Zoology, Harvard, University, Cambridge, MA; 2 specimens, St. Johns, NE, reared VII-85, CNC; Brickyard Hill Wildlife Area, Atchison Co., MO, at blacklight, J. R. Heitzman, male genit. slide MS 97199, forewing length 9.0 mm, J. R. Heitzman collection, Independence, MO (Figs. 1 & 2). Europe: Derbyshire, England, 30–VI-25, H. C. Hayward, male genit. prep. WEM 291992, forewing length 9.5 mm; Mt. Kaiserstuhl, Baden-Württemberg, Germany, 6–VII-53, E. Jäckh, forewing length 10.0 mm; Capeila, Germany, 14–VII-42, Heddergott, male genit. prep. WEM 291991, forewing length 10.0 mm, all three in U. S. National Museum of Natural History, Smithsonian Institution, Washington, DC.

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#### A HOSTPLANT EXTENSION FOR *HEMILEUCA HERA HERA* (SATURNIIDAE: HEMILEUCINAE): THREETIP SAGEBRUSH (*ARTEMISIA TRIPARTITA* RYDB.)

**Additional key words:** sagebrush sheep moth, *Artemisia tridentata*, captive-rearing.

Big sagebrush, *Artemisia tridentata* Nutt. (Asteraceae), is widely documented as the exclusive host-plant for the sagebrush sheep moth, *Hemileuca hera hera* (Harris) (Ferguson 1971, McFarland 1974, Tuskes 1984, Stone 1991, Tuskes et al. 1996). In an investigation of insects in the upper Snake River Plain of southeastern Idaho, Stafford (1987) also found larvae of *H. hera hera* only on *A. tridentata* hosts, despite the presence of *A. nova* Nelson, *A. arbuscula* Nutt., and *A. tripartita* Rydb. at the study sites. The use of *Artemisia* species other than *A. tridentata* has been reported only by Collins (1974), who observed a small number of *H. hera hera* larvae on silver sagebrush, *A. cana* Pursh.

During a series of field surveys conducted to investigate the life history of *H. hera hera* in the same general area of southeastern Idaho studied by Stafford (1987), I commonly found larvae on *A. tridentata* ssp. *wyomingensis* (Beetle & Young). However, in one mixed-sagebrush community, I observed larvae at all stages of development feeding on both *A. tridentata* ssp. *wyomingensis* and *A. tripartita* ssp. *tripartita* (hereafter abbreviated as *A. tridentata* and *A. tripartita*). In 1997 and 1998, I reared captive larvae on *A. tripartita* for the purpose of obtaining voucher speci-

mens. My observations of host associations and the results of captive-rearing are discussed in this note.

**Field-observations.** During April 1997, an intensive search was conducted of the area in which *H. hera hera* larvae were observed feeding on *A. tridentata* and *A. tripartita* hosts. Plants containing larvae were tagged and larval development was monitored weekly between May 1997 and July 1997. Larvae on both *A. tridentata* and *A. tripartita* demonstrated a life history and behavior typical of *H. hera hera* in other parts of its range. On both hosts, first through third instars generally fed gregariously and then dispersed to feed individually as fourth and fifth instars. On multiple occasions, late-instar larvae were observed to move from one *Artemisia* species to the other. Larvae often remained on the second host for several days, indicating that plants of both species were acceptable food sources.

Female *H. hera hera* in this study area also used both *A. tridentata* and *A. tripartita* as oviposition hosts (Hampton 2000). Eggs were most commonly laid on stems of both *Artemisia* species, but approximately 18% were located on the stems of other species in the sagebrush understory including *Chrysothamnus viscidiflorus* (Hook.) Nutt. (Asteraceae), *Leptodactylon*



*pungens* (Torr.) Nutt. (Polemoniaceae), and *Bromus tectorum* L. (Poaceae) (Hampton 2000). Despite these apparent oviposition “mistakes,” feeding by larvae on plants other than *Artemisia* spp. was observed only once. In the spring of 1997, several larvae developed to the third instar while feeding on green rabbitbrush (*C. viscidiflorus*). However, compared to larvae feeding on nearby sagebrush, these larvae were severely stunted. Continued searches of this plant showed no evidence that the larvae matured or pupated.

Previously documented instances of *H. hera hera* feeding on plants of genera other than *Artemisia* are also rare. Collins (1974) reported a single *H. hera hera* larva feeding on lupine (*Lupinus* sp., Fabaceae) and use of buckwheat (*Eriogonum* spp., Polygonaceae) has been reported (Tuskes 1984). These observations have been generally attributed to “adventitious” feeding or conditions associated with larval overcrowding (Collins 1974, Tuskes 1984).

**Captive-rearing.** During late June and early July of 1997, I collected 31 fourth and fifth instar *H. hera hera* larvae from plants of both *A. tridentata* and *A. tripartita* for the purpose of obtaining adult voucher specimens (archived in the entomology collection at Idaho State University, International Collection Registry ICIS).

Larvae were fed on potted *A. tripartita* plants located in screened outdoor cages. The cages were constructed of rigid wire mesh rolled into free-standing cylinders approximately 0.60 m in diameter. The cylinders were covered with 1 mm mesh nylon screen, placed over potted sagebrush plants resting on soil-filled bases of equal diameter, and pressed into the soil to form an escape-proof seal. By 21 July 1997, 22 of the 31 caterpillars had successfully pupated. On 10 November 1997, the soil-covered pupae were moved to an unheated garage where they were left in diapause. In April 1998, the cages were reconstructed and the pupae were returned to the outdoors to await eclosion. Five adult *H. hera hera* (3 females and 2 males) emerged between 11 and 26 August 1998 (see Table 1). In early September 1998, the soil bases of all cages were excavated and four potentially viable pupae were transferred to small containers and moved indoors. Two of the pupae in containers subsequently produced adults, one female on 12 September 1998, and a male on 2 October 1998. Of the 22 pupae produced in 1997, 15 were lost to various causes including parasitism by a fungus and an unidentified wasp (Ichneumonidae: Hymenoptera) (Table 1).

In April 1998, a group of first instar larvae collected from *A. tridentata* were reared in the same manner, using the same cages and *A. tripartita* plants. Cold,

TABLE 1. Summary of captive-rearing results.

	1997–1998	1998–1999
No. of initial larvae	31 <sup>a</sup>	25 <sup>b</sup>
No. of pupae produced	22 (71%)	7 <sup>c</sup> (28%)
No. of adults produced <sup>d</sup>	7 <sup>e</sup> (23%)	3 <sup>e</sup> (12%)
No. of unsuccessful pupae	15 <sup>e</sup> (48%)	4 <sup>e</sup> (16%)
Damaged in handling	1	—
Fungal parasites	7	3
Ichneumonid parasitoid	3	—
Other insect damage	1	—
Unknown causes	3	1

<sup>a</sup> Fourth and fifth instars collected between June and July 1997.  
<sup>b</sup> Estimated number of first instars collected as an aggregation in April 1998.  
<sup>c</sup> All but seven larvae were killed by cold, wet weather conditions that occurred as larvae were molting from second to third instars.  
<sup>d</sup> Dates of emergence for seven 1998 adults: ♂ 11 Aug., ♀ 23 August, ♂ 24 Aug., ♀ 26 Aug., ♀ 27 Aug., ♀ 12 Sept.<sup>f</sup>, and ♂ 2 Oct.<sup>f</sup> Dates of emergence for three 1999 adults: ♀ 3 Aug., ♂ 8 Aug., and ♀ 9 Aug.  
<sup>e</sup> Total based on the assumption that adults emerged from 1997 pupae (see item “f” below).  
<sup>f</sup> Late dates of adult eclosion may indicate same-year emergence.

wet weather killed all but seven of the approximately 25 larvae during their second molt. However, the size and vigor of the remaining larvae appeared similar to larvae observed in the field and all seven pupated by late July 1998. When cages were dismantled in early September 1998, three pupae had been destroyed by a fungal parasite. Four undamaged pupae were removed from the soil to small containers and refrigerated during November 1998 through March 1999. Three adults (1 male and 2 females) emerged between 3 and 9 August 1999 (Table 1). However, two of these individuals were dark-colored, appeared weak, and the wings of both never fully expanded.

**The potential for alternative hosts.** Fourteen species of *Artemisia* and 11 subspecies in the subgenus *Tridentatae* are found within the western United States (McArthur et al. 1998, McArthur 2000). Although *A. tridentata* and its subspecies have the greatest geographic range (McArthur 2000) and are found throughout the range of *H. hera hera* (Fig. 1), the distributions of most members of the subgenus intersect the moth’s range to some extent. The northeastern range of *H. hera hera* extends well outside the range of *A. tridentata* (Fig. 1) and beyond the ranges of all *Artemisia* species except *A. cana* (McArthur & Plummer 1978), indicating the potential for an alternate host in that area.

*Artemisia tripartita* ssp. *tripartita* is generally restricted to areas of Idaho, Washington, and Oregon (Shultz 1984), and occurs only in the central portion of the range of *H. hera hera* (Fig. 1). A second subspecies, *A. tripartita* ssp. *rupicola* Beetle, inhabits large areas of Wyoming (Beetle 1960, Shultz 1984). Although plant morphology differs markedly between *A. tripartita* and



*A. tridentata*, early leaf growth in both species (Miller & Shultz 1987) coincides with larval emergence (pers. obs.), and chemical constituents of both are similar (Kelsey & Shafizadeh 1979). However, differences in plant structure are known to influence microclimatic conditions within and around plants (Hinds & Rickard 1968, Lawton 1983, Strong et al. 1984, Pierson & Wight 1991) and can impact selection of oviposition site, larval survivorship and development, and predation dynamics in *H. hera hera* (Hampton 2000). Unlike most woody *Artemisia* species, *A. tripartita* plants can re-sprout from the roots after fire, over-grazing, or winter damage (Beetle 1960, Hironaka et al. 1983). Because *A. tridentata* plants are easily killed by fire (Beetle 1960) and take many years to regenerate from seed (Hironaka et al. 1983), the use of *A. tripartita* as an alternative host could have important implications with regard to long-term survival and viability of *H. hera hera* populations. This may be especially important in the wake of more frequent wildfire and other large-scale disturbances to sagebrush communities across the Great Basin (Knick & Rotenberry 1997, Knick 1999).

Another subspecies of *H. hera* is also known to use more than one hostplant. Both *A. tridentata* and *A. filifolia* Torr. are used as hosts by *H. hera magnifica* (Rotger), depending on the location within its range (Stone & Smith 1990, Stone et al. 1988). Because *Artemisia* species and subspecies share many chemical similarities (Kelsey & Shafizadeh 1979), it may be reasonable to expect that other species might also serve as suitable foodplants for *H. hera hera*. Nevertheless, some herbivorous insects demonstrate apparent preferences for certain subspecies and hybrids of *A. tridentata* (Messina et al. 1996) and there is evidence that some *Artemisia* species and varieties can be unsuitable hosts for *H. hera hera* larvae (McFarland 1974, Tuskes et al. 1996). The variation in secondary chemistries of *Artemisia* species and hybrids (McArthur et al. 1988, Messina et al. 1996) may influence the selection of hosts by *H. hera hera*. Although hybridization between *A. tridentata* ssp. *wyomingensis* and *A. tripartita* is a possibility, it has not been documented (B. L. Welch, pers. com.) and attempts to produce hybrids under controlled conditions have been unsuccessful (McArthur et al. 1998).

The use of other species and varieties within the genus *Artemisia* by *H. hera hera* may simply not appear more frequently in the literature because sagebrush identification and taxonomy is complicated. Prior to 1960, several species were included as subspecies within the *A. tridentata* complex (Hall & Clements 1923), but were assigned species status in later treatments (Beetle 1960, McArthur et al. 1998). For example, *A. tripartita* was formerly classified as *A. tridentata* ssp. *trifida* Hall &

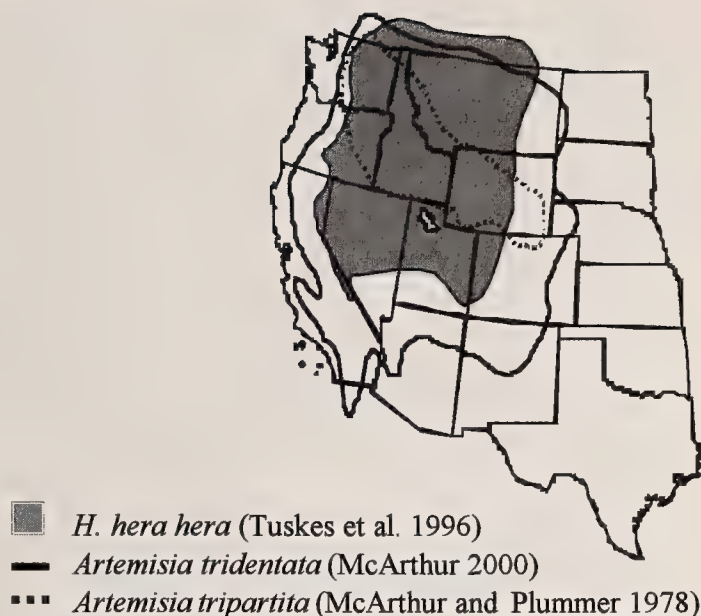


FIG. 1. The ranges of *Hemileuca hera hera* and *Artemisia* hostplants.

Clements (Hall & Clements 1923). Although leaf and plant morphologies of *A. tripartita* are distinctive, host-plant nomenclature to the level of subspecies is rarely, if ever, included in published food records for *H. hera hera*. Consequently, some accounts could refer to a number of *Artemisia* species formerly designated as subspecies of *A. tridentata*.

The use of *A. tripartita* by *H. hera hera* in southeastern Idaho provides new evidence that the sagebrush sheep moth can successfully exploit hosts other than *A. tridentata* in some parts of its range. The potential use of alternative *Artemisia* hosts by *H. hera hera* in other geographical locations, including *A. cana* in the northeastern extension of its range, warrants further investigation.

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## REDISCOVERY OF AND NOTES ON *XANTHOTHRIX RANUNCULI* FORM *ALBIPUNCTA* BARNES & BENJAMIN, 1925 (NOCTUIDAE: STIRIINAE)

**Additional key words:** discal spot, *Coreopsis*.

Barnes and Benjamin (1925) described *albipuncta* as a form of *Xanthothrix ranunculi* based on two individuals, a male holotype and a female allotype, collected 10 April 1902 at Kaweah, Tulare Co., California. The moths were described as having “head, thorax and forewing black dusted with olivaceous, the latter with a round white spot near end of cell. Secondaries blackish.”

*Xanthothrix ranunculi* was described by Henry Edwards (1878) from Havilah, Kern Co., California, and most specimens seen are from Lovejoy Buttes, Los Angeles Co., California. These moths were described as, “Primaries wholly rich buff, sometimes pale orange when very fresh, but upon some scales being removed, showing a blackish tint. Secondaries, dusky along the costa, apical margin and at base, buff in the center, and towards the anal angle. . .” Comstock and Henne

(1940) described their early stages, and reported the hostplant is *Coreopsis douglasii* (Asteraceae). Poole (1994) makes no mention of form *albipuncta*.

On 21 March 1990, I collected three individuals of a small moth flying near *Coreopsis stillmanii* (Asteraceae) on a steep, south-facing slope above the middle fork of the American River, 13 mi. NE of Auburn, Placer Co., California. One, a worn specimen, fit the description of *Xanthothrix ranunculi* form *albipuncta*; the two fresh specimens had gold forewings with a light yellow spot near the end of the cell. The habitat consisted of annual grasses and flowering plants surrounded by foothill woodland. At the same locality, in March 1998 the moths were numerous and were often seen sitting on the *Coreopsis* flower heads. More individuals were collected and the association with *Coreopsis* observed. Alvin Ludtke collected females and *Coreopsis still-*





FIG. 1. *Xanthothrix ranunculi* form *albipuncta*. Columns 1 and 2, Mariposa Co., showing variation. Column 1 top, Scotch Gulch, 6 mi. SE of Coulterville, Mariposa Co., CA, 29-III-1999, others, same locality but 22-III-2000. Column 3 Placer Co. 2 mi. E of Ruck-A-Chucky Falls, middle fork of the American River, 13 mi. NE of Auburn, Placer Co., CA. Top 27-III-1999, bottom 19-III-1998.



FIG. 2. Mature larva of *Xanthothrix ranunculi* form *albipuncta* on *Coreopsis stillmanii*. Reared *ex ovum* from a female collected 2 mi. E of Ruck-A-Chucky Falls, middle fork of the American River, 13 mi. NE of Auburn, Placer Co., CA. Scale at top of photograph in millimeters.

*manni* from the site to attempt rearing. The females oviposited on these plants, and larvae (which fed on the developing achenes) were reared through the third instar. The larvae were then moved to a perennial garden *Coreopsis*, on which they fed for a while, then died, for unknown reasons, without pupating.

In March 1999 and March 2000, D. Brown and I collected these moths southeast of Coulterville, Mariposa Co., California resting on the flower heads of *Coreopsis stillmanii*. Goldfields, *Lasthenia* (Asteraceae) were growing with the *Coreopsis* there but the moths did not rest on their flower heads. Unlike in Placer Co., the habitat there was on serpentine soils, and Buck Brush, *Ceanothus cuneatus*, dominated the flora. These moths very closely resembled the Placer Co. moths, although a greater number of them had a dull, gray-green color to the forewing, with the forewing spot closer to white. This coloring was most marked in worn individuals, but was also characteristic of some fresh individuals, on which the long scales on the forewing were a very light yellow rather than gold. No individuals were found in an April 1999 visit to the type locality. On March 18, 2001 the moths were found, again associated with *Coreopsis stillmanii*, on an area of serpentine soils in Tuolumne Co.



The Placer and Mariposa Co. moths appear more golden than the worn type of *albipuncta*, suggesting that the gold scaling on the forewings is gradually lost causing the wings to appear olivaceous in older specimens. All Mojave Desert specimens of *ranunculi* lack the yellowish spot near the apex of the discal cell that is present in *albipuncta*.

It is likely that *albipuncta* and *ranunculi* are different species. *Xanthothrix ranunculi* is golden yellow, is apparently restricted to the Mojave Desert, uses *Coreopsis douglasii* as a food plant, and lacks a forewing spot near the apex of the discal cell. *Xanthothrix ranunculi* form *albipuncta* has golden forewings and blackish hindwings, is apparently restricted to the lower, grassy foothills of the Sierra Nevada, uses *Coreopsis stillmanii* as a food plant, and has a light yellow forewing spot near the apex of the discal cell. *Philotiella speciosa* and its subspecies *bohartorum* (Lycaenidae), which also may be a separate species, display a similar disjunct distribution.

Plants were identified using Hickman (1993).

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#### ADDENDUM TO THE SPHINGIDAE OF LOUISIANA

**Additional key words:** bait traps, hawkmoths, light traps, Louisiana, sphinx moths.

The Sphingidae of Louisiana were reported by Brou and Brou (1997) in a 26-year study treating abundance, distribution, and flight periods. We listed 55 species of Sphingidae recorded for Louisiana and 46 species documented by our study. The quantity of adult sphingidae captured from 1970 to 1995 for the state of Louisiana totaled 71,836 specimens. This brief article is intended to add to and finalize our previous investigations. No newly recorded species were encountered during these four years, nor were species newly encountered in bait traps versus light traps than were previously reported. This addendum, representing four years (1996–1999) yielded 12,053 specimens

representing 36 species (Table 1). Fermenting bait traps were operated only in 1996–1997, while ultraviolet light traps were operated all four years. These additional records represent 30 consecutive years of Sphingidae records for the state of Louisiana, totaling 83,889 captured adults.

Total trap hours expended during the 30 year investigation were in excess of 1.4 million hours, involving 491,000 ultraviolet light trap hours and 913,000 fermenting bait trap hours. Specimens retained during this addendum period are deposited in Florida State Collection of Arthropods (Gainesville) and Louisiana State University (Baton Rouge).



TABLE 1. List of species and number of individuals collected between 1996 and 1999.

Species	Number of adults
1. <i>Agrius cingulata</i> (F.)	95
2. <i>Manduca sexta</i> (L.)	36
3. <i>M. quinquemaculata</i> (Haw.)	4
4. <i>M. rustica</i> (F.)	44
5. <i>M. jasminearum</i> (Guer.)	16
6. <i>Dolba hyloeus</i> (Drury)	429
7. <i>Ceratomia amyntor</i> (Geyer)	4
8. <i>C. undulosa</i> (Wlk.)	284
9. <i>C. catalpae</i> (Bdv.)	6
10. <i>C. hageni</i> (Grt.)	0
11. <i>Isoparce cupressi</i> (Bdv.)	93
12. <i>Paratreia plebeja</i> (F.)	69
13. <i>Sphinx eremitus</i> (Hbn.)	0
14. <i>S. leucophaeta</i> Clem.	0
15. <i>S. chersis</i> (Hbn.)	0
16. <i>S. franckii</i> Neum.	1
17. <i>S. kalmiae</i> J. E.Smith	33
18. <i>S. drupiferarum</i> J. E.Smith	0
19. <i>Lapara coniferarum</i> (J. E.Smith)	2452
20. <i>L. phaeobrachycerous</i> Brou	1498
21. <i>Smerinthus jamaicensis</i> (Drury)	4
22. <i>Paonias excaecatus</i> (J. E.Smith)	218
23. <i>P. myops</i> (J. E.Smith)	804
24. <i>P. astylus</i> (Drury)	16
25. <i>Laothoe juglandis</i> (J. E.Smith)	45
26. <i>Pachysphinx modesta</i> (Harr.)	0
27. <i>Pseudosphinx tetrio</i> (L.)	0
28. <i>Erynnis alope</i> (Drury)	0
29. <i>E. lassauxi</i> (Bdv.)	0
30. <i>E. ello</i> (L.)	1
31. <i>E. obscura</i> (F.)	2
32. <i>E. domingonis</i> (Btl.)	0
33. <i>Pachylia ficus</i> (L.)	0
34. <i>Aellopos titan</i> (Cram.)	0
35. <i>A. fadus</i> (Cram.)	0
36. <i>Enyo lugubris</i> (L.)	177
37. <i>Hemaris thysbe</i> (F.)	31
38. <i>H. diffinis</i> (Bdv.)	0
39. <i>Eumorpha satellita licaon</i> (Cram.)	0
40. <i>E. pandorus</i> (Hbn.)	27
41. <i>E. intermedia</i> (B. P.Clark)	3
42. <i>E. achemon</i> (Drury)	20
43. <i>E. vitis</i> (L.)	0
44. <i>E. fasciatus</i> (Sulz.)	71
45. <i>E. lubruscae</i> (L.)	0
46. <i>Sphecodina abbottii</i> (Swainson)	362
47. <i>Deidamia inscripta</i> (Harr.)	625
48. <i>Amphion floridensis</i> B. P.Clark	724
49. <i>Proserpinus gaurae</i> (J. E.Smith)	0
50. <i>Darapsa versicolor</i> (Harr.)	2
51. <i>D. myron</i> (Cram.)	2271
52. <i>D. pholus</i> (Cram.)	1344
53. <i>Xylophanes pluto</i> (F.)	0
54. <i>X. tersa</i> (L.)	182
55. <i>Hyles lineata</i> (F.)	60
<b>Total records</b>	<b>12,053</b>

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## THE CORRECT SPELLINGS AND TYPE LOCALITIES OF BUTTERFLIES NAMED FROM MOUNT RAINIER, WASHINGTON, USA

**Additional key words:** *Boloria*, *Clossiana*, *Speyeria*, *chariclea*, *titania*, *rainieri*, *mormonia*, *bischoffi*.

The original description of the taxon *Brenthis chariclea ranieri* Barnes and McDunnough, 1913 is titled “B. CHARICLEA RAINIERI subsp. nov. (Pl. II. Figs. 1–4).” The figure captions read: “Fig. 1. *Brenthis chariclea ranieri* B. & McD. Paradise Valley, Mt. Ranier. ♂ Co-type.”; “Fig. 2. *Brenthis chariclea ranieri* B. & McD. Paradise Valley, Mt. Ranier. ♀ Type.”; “Fig. 3. *Brenthis chariclea ranieri* B. & McD. Paradise Valley, Mt. Ranier. ♂ underside.”; and “Fig. 4. *Brenthis chariclea ranieri* B. & McD. Paradise Valley, Mt. Ranier. ♀ underside.” (Barnes & McDunnough 1913). The subspecies name is not otherwise mentioned in the original description. Therefore there are two spellings of the new subspecies in the original description, *rainieri* and *ranieri*, and the correct spelling must be determined through application of the International Code of Zoological Nomenclature (International Commission on Zoological Nomenclature 1999).

Statements in the original description include “HABITAT. Mt. Ranier, Wash. (July 24–31) (6–7000 ft.) (McDunnough), 7 ♂, 7 ♀. Types. Coll. Barnes.” and “The species was the commonest butterfly collected, being found all over the grassy slopes around the so-called Paradise Valley.” Immediately prior to the original description, on the same page, Barnes and McDunnough state “Two years ago we captured a long series of specimens on Mt. Ranier, Washington. . . .”, and on the previous page of the publication “Mt. Ranier” is given as the type locality of *Argynnis bischoffi washingtonia* Barnes and McDunnough. It is therefore clear that the type locality is Paradise Valley, Mt. Ranier, Washington. It is also unambiguously clear that the subspecies was named after Mt. Ranier.

The International Code of Zoological Nomenclature (International Commission on Zoological Nomenclature 1999) states:

“32.5. **Spellings that must be corrected (incorrect original spellings).**

32.5.1. If there is in the original publication itself, without recourse to any external source of information, clear evidence of an inadvertent error, such as a lapsus calami or a copyist's or printer's error, it must be corrected.”

and

“**Examples.** If an author in proposing a new species-group were to state that he or she was naming the species after Linnaeus, yet the name was published as *ninnaei*, it would be an incorrect original spelling to be corrected to *linnaei*.”

and

“33.2.2. The correction of an incorrect original spelling in accordance with Article 32.5 is a “justified emendation,” and the name thus corrected retains the authorship and date of the original spelling [Art. 19.2].

33.2.3. Any other emendation is an “unjustified emendation”. . . . [Article 33.2.3 continues with conditions under which “prevailing usage” requires use of an emendation even if it was unjustified.]

Prevailing usage (Art. 33.2.3) is clearly only a factor if article 32.5 does not apply. Articles 32.2.1 and 32.2.2 refer to the choice of correct spelling by a first reviser and are only pertinent when the incorrect spelling is not demonstrably incorrect through article 32.5, which is not the case in this example. Since article 32.5 applies, because it is unambiguous that the subspecies was named after Mt. Ranier, the incorrect spelling *rainieri* in the title of the original description must be corrected to *ranieri*. Miller and Brown (1981, taxon 589b and note 475) were incorrect in emending the spelling of the name to *rainieri*.

We have also reviewed topographical maps and other information to confirm the correspondence of the stated type locality data to modern information. Paradise Valley is a flat-bottomed mountain valley on the south side of Mt. Rainier through which runs Paradise River. This is now the most visited location in the park, with abundant alpine flowers in the summer and deep (6 meter) snow in the winter (Reese 2001). The flat bottom of Paradise Valley is at 5000–5100 feet elevation. The original description states that *ranieri* was “found all over the grassy slopes around the so-called Paradise Valley,” indicating that the true elevation at which the type series was collected may have been 5–6000 feet. The steep slopes at the upper (north) end of the valley, from which the headwaters of the Paradise River originate, rise above 6000 feet to Mt. Rainier. Hence, for lack of any strong evidence to the contrary, we recommend leaving the stated elevation of 6–7000 feet unchanged. The boundary between Pierce County and Lewis County almost exactly bisects Paradise Valley. The type specimen of *ranieri* may have originated from either County. The type locality of *Brenthis chariclea ranieri* Barnes and McDunnough, 1913 should be therefore be cited as “Paradise Valley, Mt. Ra[i]nier, [elevation] 6–7000 ft., [Pierce or Lewis County], Wash[ington], USA,” with the square brackets indicating extrapolated data.

Barnes and McDunnough (1913) also described the subspecies *Argynnis bischoffi washingtonia* (now referred to as *Speyeria mormonia washingtonia*), with a similar type locality to *ranieri*. The differences in type locality citation were in the elevation (7000 ft.) and reference to only Mt. Ranier and not Paradise Valley. This indicates that the type series of *washingtonia* was probably collected on the steep slopes above the upper (north)



end of Paradise Valley, within Pierce County. The type locality of *Argynnis bischoffi washingtonia* Barnes and McDunnough, 1913 should therefore be cited as “Mt. Ra[i]nier, [elevation] 7000 ft., [Pierce County], Wash[ington, USA],” to reflect accurately the information in the original description. It is worth noting that the spelling *bischoffii* is the original spelling (Edwards 1870) and Barnes and McDunnough’s (1913) spelling of *bischoffi* was incorrect (International Commission on Zoological Nomenclature 1999, Article 31.1).

Gunder (1932) named “*Argynnis eurynome* [= *Speyeria mormonia*] *washingtonia* B. & McD., form *ranierensis*” from specimens collected at “Paradise Valley, Mount Ranier, Pierce Co., Washington, Aug. 12, 1931.” Miller and Brown (1981) incorrectly and without explanation emended the name of this form to *rainierensis*. The correct spelling is form *ranierensis*, because it is unambiguously clear that the form was named after Mount Ranier. The type locality for form *ranierensis* should be cited as “Paradise Valley, Mount Ra[i]nier, Pierce Co[unty], Washington, [USA].”

Mount Rainier, elevation 14,411 feet, is in the center of Mount Rainier National Park. Captain George Vancouver named it in 1792 to honor Rear-Admiral Peter Rainier of the Royal Navy (Reese 2001). On 2 March 1899 President McKinley signed into law the bill that created a new national park around Mount Rainier. The national park was named after the mountain, but was misspelled “Mount Ranier National Park” in the bill. An image of the original bill, showing the misspelling, can be viewed on the Library of Congress website at <http://lcweb2.loc.gov/law/GLINv1/GLIN.html>. The official, but misspelled, name may well have been used on

signs in the park in 1911, when the specimens of *ranieri* were collected, and in 1931 when the types of *ranierensis* were collected. We made contacted the National Parks Service, but could not determine when, if ever, the name of the national park was changed to “Mount Rainier National Park”. However, it appears that up until at least 1931 the spelling “Mount Ranier” was a valid and widely used alternate spelling for Mount Rainier. This is the origin of the spelling Mount Ranier as the type locality for the two butterfly names *ranieri* Barnes and McDunnough, 1913 and *ranierensis* Gunder, 1932.

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## BOOK REVIEWS

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BUTTERFLIES THROUGH BINOCULARS: THE WEST, A FIELD GUIDE TO THE BUTTERFLIES OF WESTERN NORTH AMERICA, by Jeffrey Glassberg. 2001. Oxford University Press, Inc., 198 Madison Ave, New York, New York 10016. v–x + 373 pp., including 1076 color photos. Paperback, 8.25 × 5.5 inches, ISBN: 019-510669-5, \$19.95.

As organisms and their habitats succumb to the weight of encroaching humanity, we race to understand a little about our surroundings in hopes of conserving what we have yet to destroy. We focus on groups with public appeal and use them to promote awareness of the negative impact that results from severely altering natural habitats. Butterflies have become the focus of some conservation inclined people, like birds before them. Jeffrey Glassberg's Butterflies through Binoculars (BTB) series gives us a nonconsumptive approach via the use of lenses, allowing for an up-close view of butterfly biology and identification without interfering with normal butterfly behavior—conservation, apparently, being the ultimate goal. BTB-The West, the latest in the BTB series, continues Glassberg's view of butterflies and his photography of western North American butterfly fauna.

The book has over 1100 photographs of butterflies (western United States and the southern part of western Canada east to include all of Saskatchewan and the United States to just south of Houston), mostly in poses one would observe in the field. Accurate size relationships of species included on a page allow the user to compare size of similar looking species, and magnification or reduction from life size is indicated on each page. Some species have an inset of a different view of the species in question, while others have a black or white line to indicate a diagnostic feature. Photographs were arranged so that similar species are shown in similar poses, making comparisons easier. Dates and locations of the photographs are indicated in the rear of the book, providing a record of seasonal variation at particular localities. Species accounts that accompany photographs include habitat, abundance/phenological, host plant, range, and other information. Color coded distribution maps indicate brood numbers and species rarity or loss at a particular locality. Species and respective families are roughly organized phylogenetically, and common names, as recognized by the North American Butterfly Association's 1995 Checklist and English names of North American Butterflies are utilized throughout.

The remainder of the book includes introductory sections on the use of binoculars and how and where to find butterflies (nectar sources, mud puddles, hill-tops, etc.) and how to identify them through binoculars, and a section on butterfly photography for those inexperienced behind the lens. Subsections under photography include information on equipment, photo etiquette, and caring for and viewing your photographs. Brief sections on butterfly anatomy, biology, behavior and gardening are also included. Other introductory sections include Glassberg's thoughts on conservation, netting butterflies, and commercially raised butterflies, and express his concern for these issues and the overall health of our butterfly fauna. A brief section on Hawaiian butterfly fauna, rare strays observed out west, and dubiously reported species can be found in the back of the guide. Supplementary text on species or groups that present identification problems (i.e., *Euphilotes* blues, Greater Fritillaries) are also included in the books rear and intended to ease identification difficulties in some regions of western United States. Foodplant scientific names, a list of major organizations concerned with butterflies, a short glossary of butterfly terms, and a bibliography of western North American butterfly literature are also included. The dimensions of the book are appropriate for a field guide, and print on pages holds up if moistened.

This guide is written and intended for novice lepidopterists. Those seeking a complete list or photographs of all species and subspecies in western North America, or a thorough taxonomic treatment will not find it here. The repeated use of the term “antennas” on page 10 (“*antennas*” are conductors by which electromagnetic waves are sent out or received and “*antennae*” are movable, sensory appendages occurring on the heads of insects and other arthropods) and “genuses” on pages 182 and 224 (genera was used on page 56) also give subtle hints to the intended audience.

It is admirable that Glassberg suggests an approach to butterfly observation, identification and conservation with the production of the BTB series, a method that incidentally has been used for more than 50 years among tropical naturalists. His message, however, is over-biased to simple observation of butterflies through lenses for biology and identification purposes rather than legitimate, scientific research that is essential to better understand these insects. There is already a mountain of bureaucratic nonsense that legitimate scientific research must contend with, a trend that will surely hinder rather than further our understanding of species relationships within environments. As the majority of Glassberg's audience will be novices, he



should not misinform with ideas that we can understand all butterfly biology and identification without research requiring sampling (yes, at times with a net) a small fraction of an overall species pool (very few collectors have used their nets to decimate the remaining populations of declining butterflies). In this regard, the book does not address the importance of conservation with a complete insight into the study of Lepidoptera. We absolutely cannot, and throughout history we could not have, come to the level of understanding (especially the accurate identification) of butterflies by observing them through binoculars or photographs, and much remains to be discovered, even in North America. This book is for novice (perhaps naïve?) lepidopterists beginning a hobby, but would be of marginal use to the experienced lepidopterist.

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THE MILLENNIUM ATLAS OF BUTTERFLIES IN BRITAIN AND IRELAND, by J. Asher, M. Warren, R. Fox, P. Harding, G. Jeffcoate and S. Jeffcoate, Oxford University Press, 456 pp.; 270 color illus: publication 2001; Cloth ISBN: 0-19-850565-5; Cloth Price: \$40.00.

The United Kingdom has had virtually no intact habitat for the past 500 years and it sports less than 100 species of butterflies. Nonetheless, there are more books treating the butterflies of the British Isles than anywhere else on earth. So why do we need another book? Despite the area of coverage and topic this is not simply another butterfly book. It is a revelation. The six collaborative authors, whose professions include physics, ecology, biochemistry and medicine have not produced something assembled by committee. Rather, the fruits of their labor resulted in a decidedly readable book that is comprehensive, visually beautiful, scholarly and eminently valuable to a wide audience. The information content and style of the Millennium Atlas is a remarkable benchmark that future butterfly books must attempt to emulate.

The backbone of the Millennium Atlas is the incredibly comprehensive understanding of butterfly distributions. Collated by over 60 people in charge of coordinating local records, hundreds of thousands of observations were verified, entered into a central data-

base, plotted on a detailed geographic grid map whose resolution ranges from 10 km<sup>2</sup> to 100 m<sup>2</sup>, and then analyzed in the context of records spanning over 100 years. Thousands of volunteers (amateur and professional) contributed to what, in some cases, consist of many thousands of observations per species on each map. This is the template for the Millennium Atlas. The result is a magnificent understanding of the historical variation in distribution, population ecology, reproductive biology, colony dynamics, food plants, habitat use of each species, and a chronology of changes that reveal conservation successes, threats and failures.

The detailed species accounts draw from the comprehensive database and, of course, form the corpus of the book. Each account provides a full-page distribution map, a color photograph of the butterfly taken in the wild, and a complete account of food plants, habitat, lifecycle and colony structure, local distributional trends contrasted with those on the European mainland, a summary of the ecological and conservation outlook for each species, and references to recent literature. Each species account is a pleasure to read, and a work of art into the bargain. Therefore the book will be of use to virtually anyone with an interest in butterflies and their place in nature.

Tucked away at the end are nine appendices ranging in content from vernacular names and addresses where contributing data should be sent, to lucid graphs showing dynamical changes in the abundance and distribution of many species. These are followed by a comprehensive bibliography that provides the reader with a tremendous amount of research possibility. Calling these sections thorough hardly gets into the ballpark, or if you prefer, the cricket pitch. These sections are vital examples of how scholarly information can be presented in admirable and easily accessible form.

This volume resonates a cultural history that emphasizes cognizance of the natural world. For generations, denizens of the British Isles have shown an abiding interest in natural history, a proclivity to make abundant and accurate observations, share them, and interpret those observations for understanding wildlife and its conservation. Such a historical cultural interest in butterflies has fostered, and ultimately led to, the Millennium Atlas. However, the Millennium Atlas is not a finished work that heralds the end of butterfly study in Britain. Rather, the recent collaborative efforts of many European biologists working on butterflies in a fragmented landscape attests to it being a springboard to further refine our dynamic range of understanding butterflies. In producing the Millennium Atlas the cultural heirs of Darwinism elegantly demon-



strate the evolution of butterfly populations in the context of a changing environment. Those of us who work in areas where so little is known about butterflies may be daunted by such an effort. Nevertheless, it is clear we must strive toward its example.

Sturdily bound, filled with illustrations and information, and inexpensive, this book is uniquely outstanding in many ways. However, I especially appreciated one aspect of it; the subtle yet pervasive conservation underpinning based on the study of butterflies. If I read the message correctly it might be paraphrased in a more general way: appreciate and learn from nature before it vanishes into the increasingly greedy maw of the human dominated landscape. That is to say, the game is not just about collecting and writing epitaphs of colorful insects. It is about preventing the ecological holocausts that surround us, and surviving. As the song title suggests, now is the time.

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BUTTERFLIES THROUGH BINOCULARS: THE EAST. A FIELD GUIDE TO THE BUTTERFLIES OF EASTERN NORTH AMERICA, by J. Glassberg. 1999. Oxford University Press. \$18.95. ISBN 0-19-510668-7

#### HOW MUCH SCIENCE IS TOO LITTLE?

The practice of butterfly watching has rocketed in recent years, fueled primarily by increasingly accessible field guides equipped with easy shortcuts to identification, technological advances in photography, and numerous organizations, local and national, devoted to furthering public awareness of butterflies and their diversity. Butterfly watching, a healthy medium for natural history education, has realized considerable popularity not just among weekend naturalists and recovering bird-watchers, but also among educators and even professional lepidopterists that participate in local butterfly counts. Dr. Glassberg's *Butterflies through Binoculars: The East* (hereafter BTB) is likely to surpass previous guides' popularity among butterfly watching enthusiasts, and to that end it serves as a photographic guide for most eastern butterflies. Unfortunately, the general utility of this book is reduced sharply by several shortcomings, all of them related to the furtherance of lepidopteran science and science-based conservation.

It is difficult to decide in what spirit to review this book. It is clearly a volume intended for hobbyists

(which is fine), but at the same time the purview of its influence is intended to include matters of scientific import, and it includes promotional material linked to the North American Butterfly Association (NABA). The historical and organizational context from which the butterfly-watching movement has sprung is plain within the pages of BTB, and I therefore view it as impossible to review this book and some of the information presented therein independently of similar messages published by NABA. It is my hope that a contextual review of this kind will add more light than heat. Regardless, after tending to the book's technical aspects, I will proceed to its message.

First to the nitty gritty. The meat of BTB is of course its 283 species accounts and accompanying photographs. Again, through these, BTB is a fine introduction to observing butterflies of eastern North America. Species accounts include identification cues, geographic range maps (which accompany the plates), some life history information, including primary host plants and extensive flight season data in the form of "phenograms" which consist of rough relative abundance by month in four geographically separated states (WI, NY, NC, and LA) generated in consultation with various local experts (no use of collection data is referenced). The lack of detailed descriptions should not be viewed as a shortcoming, assuming the guide's primary target audience comprises hobbyists and prospective inventorists. The identification cues are by and large well crafted, with the exception of their reliance on comparative observation: Size measurements for species are not generally given, but evaluated with reference to other butterflies. Field diagnoses, when present, are emboldened, and brief descriptions accompanying plates make quick identification easy and reduce the need for page flipping. The photographic quality is generally quite good (with a few exceptions), and should help butterfly watchers get a feel for what various species look like in vivo, although field marks are not consistently delineated. The photographs are also carefully scaled against others on the plate. In any event, BTB should serve as a step towards identifying butterflies reliably in the field, and therefore meets its purpose.

The text comprising the book's introduction includes sections on butterfly photography, butterfly gardening, tips on finding butterflies, and butterfly biology. There is no discussion of proper vouchering, collecting, or rearing techniques or protocols, nor any broad discussion of butterfly taxonomy or systematics except for some remarks buried in the species accounts. With those exceptions, this material serves as an adequate introduction for the casual butterflyer.



Text following the species accounts includes a bibliography and a short glossary of terms.

I detect three principal shortcomings in the book's message, all associated with teaching science-based natural history and the relevance of that science to conservation of landscapes and species. First, Dr. Glassberg's dismissal of the nomenclatural process combined with the assertion that butterfly taxonomy, including both scientific and common names, is being "standardized" (p. 33) by NABA is a serious shortcoming. It also may render BTB impotent in serious bioinventories, butterfly counts, or identifying populations of cryptic species. Second, while no doubt well meaning, Dr. Glassberg makes a number of misleading comments about managing butterfly habitat, specifically fire management, that may oversimplify and exacerbate an already controversial conservation issue. Third, BTB's strident indictments of collecting utterly fail to mention the critical importance of collections not only to the study of butterflies, but also the furtherance of taxonomy, systematics, and the conservation and protection of threatened species.

There have always been nomenclatural controversies in the butterfly literature, for that is the nature of science: To modify existing taxonomy as new entities are discovered and described and as recent information is brought to bear on our imperfect understanding of nature. The proliferation of names is perhaps particularly acute in the most showy organisms, including birds, butterflies, and tiger beetles, because the attention they draw from hobbyists leads inevitably to the discovery of novel forms that are subsequently described and all too often given subspecific or infrasubspecific epithets. To be sure, keeping up with current nomenclature by tracking the most recent revisions and extracting valid names is a difficult task, one deemed necessary for scholars but annoying to those with a more casual interest. To be sure, the existence of privately published, non-peer-reviewed journals that never make their way to libraries but in which new species and subspecies are regularly described is a bane to taxonomy, and frustrating to anyone attempting to incorporate current nomenclature into field guides. It is thus not uncommon for authors to prefer, explicitly or otherwise, particular taxonomic arrangements on an ad hoc basis. The nomenclature in *BTB*, both scientific and vernacular, follows NABA's *Checklist and English Names of North American Butterflies*. And while there are some differences of opinion and treatment of taxonomic status are evident between *BTB* and other field guides, for example, the most pointed remarks in *BTB* are directed at the nomenclatural process itself. Obviously dissatisfied

with the state of flux in North American butterfly nomenclature, Dr. Glassberg writes (p. 33):

"Before the NABA checklist was published in 1995, each author of a book about butterflies used whatever set of names struck his or her fancy. The result has been a confusing plethora of names that has bewildered the uninitiated and made it more difficult for the public to become involved with butterflies. We are now on the road toward standardization, although this process will take years to be completed."

Later Dr. Glassberg writes (p. 53) in the context of the species account for the Mustard White *Pieris napi*:

"There is some recent evidence that the Mustard White complex may consist of a number of different species and a number of books have appeared that jump on this bandwagon. Changes in well established names should be made in works intended for the public only if the **published evidence is overwhelming** [emboldening as in *BTB*] that the change is correct."

Notwithstanding that fact that, like many other strong opinions expressed in *BTB*, these statements are unaccompanied by specific references, these assertions also belie either a fundamental misunderstanding or a disregard for the scientific process and its critical value to biological conservation. As most lepidopterists know, there are a number of competing endeavors to "standardize" butterfly taxonomy. Difficult as it may be for those with a superficial interest in butterflies to keep up with the technical literature, are we to believe that taxonomic stability, via the acceptance of one person's sanctioned list is more important than taxonomic progress via scholarly study? Dr. Glassberg seems to find taxonomy and systematics so trivial as to make them beholden to the hobbyist. In certain cases (e.g., p. 153), taxonomic progress is explicitly ignored and excused only in order to remain consistent with the NABA checklist.

Unfortunately, the problem goes further: NABA publishes the results of annual butterfly counts, but with little quality control. Thus it is easy for erroneous records to proliferate in print, and such apparent "data" could, if taken seriously, prove fatal to distributional revisions and local conservation efforts. For example, I recently encountered a local butterfly checklist, compiled by an avid (and talented) butterfly watcher, encouraged by a prominent international conservation organization, and copyrighted. The checklist consisted primarily of records previously published by lepidopterists (who were not credited) and a number of new records for the region in question for which no specimen vouchers exist. Some of these species were described as occurring commonly. It might be worth-



while to contemplate the impact of such information should these species ever fall in need of protection. Consider, for example, the unnecessary obstacle to securing protection of a species presented when indications that it is abundant are disseminated. Such scenarios are only worsened when taxonomic progress is ignored in favor of a popular "standard." Bottom line: The combination of inflexible and possibly questionable standardization with an unverifiable system of record keeping renders any inventories or butterfly counts meaningless without substantial follow up. "Standardization" won't change the valid names, and if butterfly watchers promote ignoring those, then their records will be even more meaningless.

Dr. Glassberg's own anti-collecting agenda, and that of his organization, NABA, is well known. But as with a number of issues on which Dr. Glassberg purports to speak authoritatively, intelligent discussion of this complicated and controversial issue is done a disservice by the author's treatment in BTB and elsewhere. As a lifelong conservationist and lepidopterist, I have been impressed by the unique ability of the lepidopterist community to integrate professional biologists with so-called "amateurs." I think this is recognized by most as one of the major strengths of lepidopteran research. True, controversies have arisen with respect to such issues as collecting regulations and the listing of endangered species, and irresponsible collectors do indeed exist. But in my experience those lepidopterists most effective at resolving such issues have done so by thinking clearly, speaking articulately, collecting hard data, writing with skill and scholarship, and all without resorting to divisive tirades. Alas, such cannot be said of BTB.

At times, Dr. Glassberg's stance on collecting (and nomenclatural standards) appears predicated on the notion that our understanding of the North American fauna is sufficient, if not complete. One could, perhaps, make such a case for birds, and butterflies' being the birds of the insect world; the temptation to think likewise for them is perhaps understandable—at least for a birdwatcher. But think for a moment on the real state of lepidopteran taxonomy. Do we really have a complete enough understanding of butterfly variation, even in the conterminous United States, to stop studying it? I know of numerous recently discovered or undescribed North American species. Lepidoptera are notorious for sudden range changes, both contractions and expansions, as well as for host plant shifts and rapid speciation events. Regulators and legislators do not frequently distinguish recreational from scientific collecting, and if scientific collecting were removed

from the equation, the endeavors of scholarly research would be hamstrung. The question is whether serious scientific research should take a back seat to the personal views, however noble, of those who don't understand the importance of collecting.

But the importance of collections is certainly not limited to the realm of systematics. Our understanding of conservation priorities would not exist without the information contained in zoology collections and herbaria. Importantly, our ability to protect populations and use the occurrences of rare organisms to prevent destructive development and land use practices often depends on voucher specimens' being deposited in scientific collections. I have known would-be developers to contest the occurrence of rare Lepidoptera on their properties, often during conservation commission hearings in mid-winter when vouchering is impossible, and were it not for voucher specimens in collections, important natural areas would have suffered.

It seems to me that Dr. Glassberg is too busy proselytizing to present a balanced discussion, or to bother mentioning the importance of scientific collections. Indeed, he appears to go to considerable lengths to downplay the potential role of amateurs in contributing to them. The recent *Dragonflies through Binoculars* field guide, published under the auspices of NABA, contains not an iota of information on how to properly prepare dragonfly and damselfly specimens. Here is a group of organisms about which we know significantly less distributional information than butterflies, presenting an outstanding opportunity for amateur naturalists to make valuable contributions to science and conservation. For someone so concerned about the public's access to information, Dr. Glassberg seems content to limit it selectively. I can't wait to see *Moths through Binoculars*.

Assuming trumping nomenclatural practices will amount to nothing, perhaps the most disturbing and disingenuous aspect of Dr. Glassberg's agenda is his stance on conservation. He describes (p. 27) conservation as the "raison d'être of this book" and to the extent that it will help instill an appreciation of the natural world and enhance access to its study, it may make a contribution. Unfortunately, both BTB's message and its intended furtherance of conservation are hampered by a series of misleading comments (as well as by the adherence to a rogue taxonomy). Among the more disingenuous are those directed at the use of prescribed burning in managing natural areas. In Dr. Glassberg's (p. 28) words, fire is an "often misguided conservation tool," and goes on to smear the conservation community (p. 29):



"Unfortunately, some of the conservation community and groups charged with the management of our natural areas have made a devil's embrace of fire—"fire is good at keeping areas open, let's burn like crazy."

Dr. Glassberg only begrudgingly acknowledges the importance of responsible fire management, but his overall message is to alert naïve readers to what he characterizes as widespread irresponsibility in the application of prescribed burning by land managers. Granted, we are all aware of examples of poor fire management, much as we know of examples of irresponsible politics, business practices and, yes, collecting. But the fact remains that only a small percentage of North America's fire dependent communities are currently being managed with fire at all.

Later, he writes (p. 30):

"[A] conservation professional, trained to look for "pure" examples of native habitats, may take one look at these weedy fields [containing important nectar sources] and turn up her/his nose."

One is left to wonder whose training and credentials in entomology or conservation are worthy of Dr. Glassberg's approbation.

It is interesting to observe that BTB's crusade against science and science-based conservation has been extended in an indictment of how conservation agencies operate. Using NABA as a vehicle, Dr. Glassberg has recently called upon The Nature Conservancy and the Heritage Program network to release information on locations of threatened plant and animal occurrences, arguing that the public should have unlimited access to such information (Glassberg, 2001). In a recent editorial of *American Butterflies* Glassberg (2001:2), writes:

"The Nature Conservancy, other conservation organizations, and government agencies charged with protecting our flora and fauna, keep the locations of rare plants and animals a secret with the best of intentions: obsessive collectors are a threat—especially to certain populations of rare orchids, cactuses [sic], butterflies, and reptiles."

This is an interesting, but inaccurate and incomplete characterization of why threatened species information is kept confidential. In fact, most of the reasons have nothing whatsoever to do with collectors, but rather with protecting the rights of landowners and protecting the most vulnerable sites from habitat destruction. As anyone with experience in serious bioinventories and conservation assessment knows, many private landowners would be loathe to cooperate with conservation endeavors if anyone could access rare

species information for their properties. In my experience, protecting landowner privacy has been critical to conserving some of North America's most significant natural areas. Equally important is the issue of illegal habitat destruction. What is to prevent a would-be developer of a shopping center in a wetland, for example, of bulldozing the site at midnight upon finding out it contains a colony of some rare orchid. No rare butterfly or orchid, no hassles with Fish and Wildlife. It may sound trite, but it happens, and clearly tightening collecting regulations is not a solution. Serious scholarly study is.

Unfortunately, rather than contribute to disseminating useful information and understanding to the public, it appears that Dr. Glassberg prefers an alarmist route. In the same editorial Glassberg (2001:2) writes:

"*Butterflies through binoculars: The East* describes how collectors killed the last Mitchell's Satyrs in New Jersey, invading private property despite the fact that the owner, in a valiant attempt to save the butterflies, encircled the land with chain link fences and posted guard dogs."

But perhaps the most telling quote from the editorial is this:

"Last summer, NABA petitioned the U.S. Fish and Wildlife Service to list Miami Blues as federally endangered on an emergency basis. We decided to keep the location of the colony secret until listing could provide some protection. While I understand that the petition was favorable [sic] received, the Department of Interior subsequently issued a moratorium on all listings and it is unclear when, if ever, this species will be protected. So, *I have decided to make the location of the colony public* [my italics added]. I hope that Secretary of the Interior Norton acts to list this species and that Florida legislators enact laws that provide real protection, before it too late, but I am not optimistic. So, my advice to you is to see these butterflies, at the northern end of Bahia Honda State Park, along Silver Palms Nature Trail, while you still can. But please don't tell anyone else."

Now let us get this straight: Even given that the site occurs in a state park, presumably protected from development, Dr. Glassberg divulged specific site information in virtually the same breath as noting that the maximum fine is \$50 and that prospects for serious protection are unlikely. Even if illegal collecting were a threat (which for all I know it might be in this case), hasn't Dr. Glassberg just declared open season on this butterfly?



To many it is unfortunate that Dr. Glassberg chooses to treat complex and controversial scientific issues that bear on the discovery and understanding of nature by resorting to misinformation and spurious appeals from the safety of his editorial fiefdom. But by allowing the propaganda to spill into BTB, he corrupts a potentially useful book with an agenda-driven crusade against science and scientific conservation. As such, much of BTB's utility is lost through the use of renege nomenclature and idiosyncratic presentation of important issues.

In summary, BTB is valuable as an introduction to observing and photographing butterflies, but its failure to deal responsibly with serious conservation-related and scientific issues can, in my opinion, only result in further muddying waters in dire need of clearer solutions.

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CATALOGUE OF THE GENERA *OENEIS* AND *DAVIDINA*, by Vladimir Lukhtanov and Ulf Eitschberger. Part 11 and Supplement 4 of E. Bauer and T. Frankenbach, eds., *BUTTERFLIES OF THE WORLD*, Goecke and Evers, Keltern, Germany, 2000 (Part 11, Plates) and 2001 (Supplement 4, Text). Plates (28 plates + 12pp; ISBN 3-931374-81-5) and text (37pp.; ISBN 3-931374-52-1) available from Antiquariat Goecke & Evers, Ihn. Erich Bauer, Sportplatzweg 5, 75210 Keltern, Germany (www.insecta.de). Prices Euro 22.50 (plates) and 20.00 (text).

This work, Part 11 of the ongoing *Butterflies of the World* series edited by Bauer and Frankenbach, is a complete illustrated catalog of the genera *Oeneis* and *Davidina* (Lepidoptera: Nymphalidae, Satyrinae, Oeneini). The Plates volume comprises 28 excellent color pages that show, at life size, examples of each of the 199 taxa catalogued. In general, both sexes are illustrated with the upper- and under-sides of each specimen shown on facing plates. This volume includes complete data (cited verbatim from the specimen labels) and brief discussions of the distribution of each taxon. Thirty-five of the approximately 350 individual specimens illustrated are primary types. Incidentally,

the German-language edition of Part 11 (ISBN 1-931374-80-7) was published before the English version and includes the original descriptions of *Oeneis buddha greishuberi*, *O. b. frankenbachi*, and *O. tarpeja baueri*. These descriptions are not in the English version.

The Text, published as Supplement 4 to Part 11, includes a key to the 10 species-groups recognized by the authors and a discussion of each species and subspecies. Full citations to the original descriptions, complete synonymies, locations of type material, and excellent-quality distribution maps are provided. Male and female genitalia are shown for several taxa in each species-group. The English text includes description of one new subspecies (*Oeneis nanna taimyrica*), absent from the German edition. In addition, three neo- or lectotypes are designated and 3 new combinations are established, and 1 species and 2 subspecies names are reduced to synonymy. The tribe Davidini Cho Io 1998 is synonymized with Oeneini Wheeler 1903.

It is a lovely thing to have before one's eyes a complete holarctic genus, males and females, dorsal and ventral. This is especially true in the case of a genus whose speciation has been extensive in the mountains of central Asia and China, where the existence of such outstanding species as *mongolica*, *urda*, and *buddha* is unsuspected by perhaps most North American lepidopterists. Likewise, it is a revelation to see specimens of *jutta* ssp. from localities ranging from Colorado to the Altai mountains on the western border of Mongolia to Siberia. And the two strange, pierid-like Chinese species of *Davidina* (with genitalia very close to *Oeneis* but distinct venation) are like nothing else among the satyrs.

*Oeneis* is a difficult genus and the authors are careful to point out a number of areas where further research is needed. For instance, *lucilla* Barnes and McDonnough 1918 is retained as a *melissa* ssp, but full species rank is "not excluded". It is pointed out that adult morphology is insufficient to resolve difficulties in taxonomy of the *O. norna* group (*norna*, *rosovi*, *polixenes*, *philipi*, *actaeoides*) and that study of DNA and immature stages is needed. *O. ivallda* (Mead 1878) is retained but its conspecificity with *chryxus* "cannot be excluded".

This work was made possible largely through assemblage, in the Entomologische Museum Eitschberger, of a worldwide collection of 4400 specimens of *Oeneis*. Through study of this material (supplemented by research in the Zoologische Staatssammlung in Munich and the Zoological Institute in St. Petersburg, Russia, and study of material from the private collections of Grieshuber, Zhou, Strohle, Tremblay, Ferris, and others), Lukhtanov and Eitschberger have produced a work that combines solid scholarship and elegant pre-



sensation. The reasonably priced work should be on the shelf of any lepidopterist with an interest in montane and arctic Satyrinae.

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THE MOTHS AND BUTTERFLIES OF GREAT BRITAIN AND IRELAND, vol. 4, edited by A. M. Emmet and J. R. Langmaid. 2002. Published by Harley Books, Martins, Great Horkesley, Colchester, Essex CO6 4AH, England. Part 1 [Oecophoridae, Ethmiidae, Autostichidae, Blastobasidae, Batrachedridae, Agonoxenidae, Momphidae, Cosmopterigidae, Scythrididae]: 326 pp., 95 text figures, 146 maps, 13 color plates; Part 2 [Gelechiidae]: 277 pages, 63 text figures, 161 maps, 6 color plates. Hardback, 26.2 × 20.8 cm, ISBN 0 946589 63 1 [set], ISBN 0 946589 66 6 [part 1], ISBN 0 946589 67 4 [part 2]. Price £80.00 [pounds sterling] per part, \$150.00 jacketed set excluding postage, available from publisher.

This two-part volume is beautifully produced: the typography is clear; the line drawings of genitalia, heads, venation, and larval activity are extremely well done and accurate; and the color plates are outstanding. Second, it represents a clear, concise guide to the gelechioid fauna [exclusive of Coleophorinae and Elachistinae treated in volume 3] of Great Britain and Ireland. This work is not, and does not pretend to be, revisionary. Nomenclature closely follows the most recent comprehensive list of taxa presented by John Bradley (*Log book of British Lepidoptera*, 2000). Thirteen authors contributed the nine families (147 species) in part 1, 10 to the Gelechiidae (160 species) in part 2.

In my early years as a budding systematist the only line drawings of microlepidopteran genital characters were in *The genitalia of the tineid families of the Lepidoptera of the British Islands* by Pierce and Metcalf (1935). They were relatively crude and did not well illustrate many important features; however, they formed the basis of my knowledge of the western European gelechioid fauna for many years. With the publication of volume 4 of *The Moths and Butterflies of Great Britain and Ireland* this body of information has been advanced significantly.

Family-group treatments comprise a statement on geographic distribution, classification, morphologic characters of adults and immatures, larval hosts and habits, pupation sites, phenology, adult habits, a checklist, identification key to genera, illustrations of male

and female genitalia, and references. Particularly useful is the illustrated key to the genera of Gelechiidae based on male genital characters. All genera and species are characterized following the pattern for family-groups but with the addition of the synonymy and literature citation for each name, illustration of venation for each genus, lateral views of selected heads, a distribution map for each species, larval hosts and habits, and adult habits and summary of geographic distribution. The historical record of each species provides insights to faunal changes. Specific variation is noted, and contrasts with similar species are clear. Much valuable information, which should prove useful for other temperate taxa, is contained for each taxon.

The quantity of life history information is impressive. Beyond the relatively standard discussion of larval appearance and host plants are treatments of larval, pupal, and adult behavior; habitats where adults may be found; diel activity of adults; and history of occurrence. The latter reveals interesting and useful information such as: 1) species known only from Great Britain and collected once, *Euclemensia woodiella* (Curtis); 2) species collected once in Great Britain but naturally occurring elsewhere, *Epicallima formosella* ([Denis & Schiffermüller]); 3) species known from a single locality and regularly collected (*Monochroa niphognatha* (Gozmány), *Metznaria littorella* (Douglas)); 4) species very infrequently collected (*Dichomeris ustalella* (F.) collected in 1861, 1987, and 1999); 5) species with general occurrence (*Agonopterix nervosa* (Haworth) and *Endrosis sarcitrella* (L.)); and 6) introductions (*Scythris inspersella* (Hübner)). Because collection data have been, and continue to be, collected and databased, and detailed knowledge of larval hosts has accumulated, it is possible that realistic statements about abundance and distribution of gelechioid species can be made for the region and remedies proposed for maintenance of restricted populations.

An anomalous feature of the entire series is a set of essays/discussions on topics related to Lepidoptera. In volume 4(1) (pp. 11–41, col. pl. A–F, fig. 1–6, tab. 1–3) J. Rydell and M. R. Young have an excellent review “The Ecology and evolution of Lepidopteran defences against bats,” which deserves more broad readership than is likely when the title appears solely in the table of contents.

This volume sets a very high standard for comparable works on the fauna of individual countries. I congratulate all involved in the text, illustration, and production for an excellent product.

RONALD W. HODGES, 85253 Ridgetop Drive, Eugene, Oregon, 97405-9535 USA







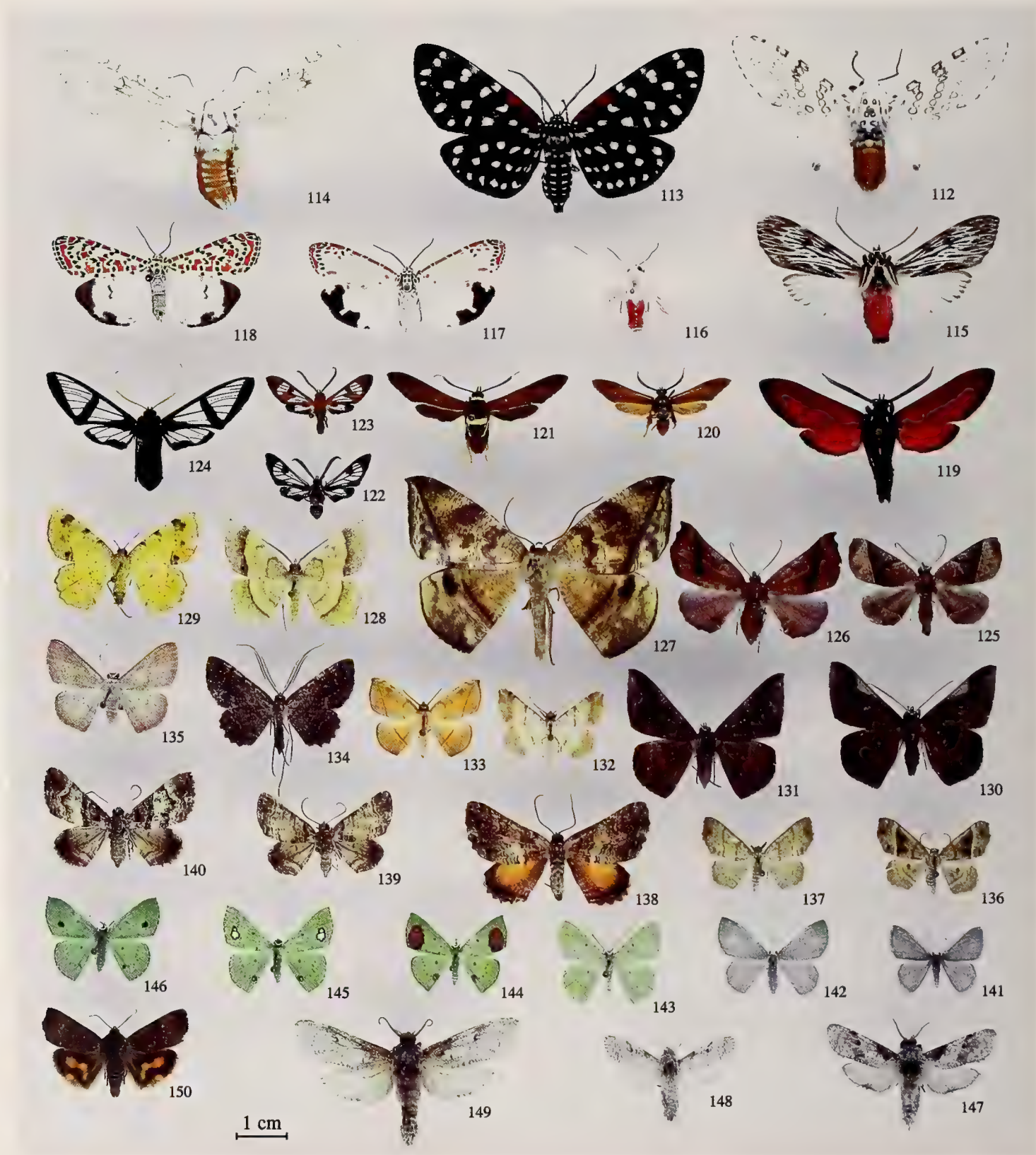
## ERRATA

*Journal of the Lepidopterists' Society*  
56(3), 2002, 191–192

### THE LARGE MOTHS OF GUANA ISLAND, BRITISH VIRGIN ISLANDS: A SURVEY OF EFFICIENT COLONIZERS (SPHINGIDAE, NOTODONTIDAE, NOCTUIDAE, ARCTIIDAE, GEOMETRIDAE, HYBLAEIDAE, COSSIDAE)

In the above paper by Vitor O. Becker and Scott E. Miller (*Journal of the Lepidopterists' Society* 56(1):9–44), specimens that compose a plate were numbered incorrectly. The corrected figure numbers and accompanying legend are given here.





FIGS. 112–150. Arctiidae (112–124), Geometridae (125–146), Cossidae (147–149) and Hyblaeidae (150) (specimens from Guana, unless stated otherwise). 112, *Hypercompe simplex*, male (Puerto Rico); 113, *Composia credula*, male; 114, *H. simplex*, female; 115, *Calidota strigosa*, male; 116, *Eupseudosoma involutum*, male (Puerto Rico); 117, *Utetheisa ornatrix*, male; 118, *U. pulchella*, female (Brazil); 119, *Empyreuma pugnione*, male; 120, *Horama panthalon*, male; 121, *H. pretus*, male; 122, *Cosmosoma achemon*, male (St. Thomas); 123, *Eunomia colombina*, male; 124, *Nyridela chalciope*, female (Cuba); 125, *Pero rectisectaria*, male; 126, *P. rectisectaria* female; 127, *Oxydia vesulia*, male; 128, *Erastria decrepitaria*, male (Cuba); 129, *E. decrepitaria*, female; 130, *Sphacelodes fusilineatus*, male; 131, *S. fusilineatus*, female; 132, *Macaria paleolata*, male; 133, *Patalene ephyrata*, male; 134, *Almodes terraria*, male (Bahamas); 135, *Semaepus malefidarius*, male; 136, *Leptostales noctuata*, male; 137, *L. noctuata*, female; 138, *Obila praecurraria*, female (Tortola); 139, *P. defensata*, male; 140, *P. defensata*, female; 141, *Eueana simplaria* male; 142, *E. simplaria* female; 143, *Phrudocentra centrifugarium*, male; 144, *P. centrifugarium*, female (Cuba); 145, 146, *P. centrifugarium*, females; 147–149, *Psychonotua personalis*, males; 150, *Hyblaea puera*, male (Cuba).



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**Cover illustration:** Detail of the forewing ventral surface of *Morpho achilles* (Nymphalidae).



# JOURNAL OF THE LEPIDOPTERISTS' SOCIETY

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## EXPERIENCE-RELATED CHANGES IN THE BRAIN OF *AGRAULIS VANILLAE* (L.) (NYMPHALIDAE)

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**ABSTRACT.** In the brain of *Agraulis vanillae*, the size of the brain regions involved in the processing of olfactory information was found to depend on the butterfly's experience. Butterflies collected in nature have olfactory glomeruli and mushroom body calyces of larger relative size than do butterflies reared and kept in the laboratory in isolation from normal environmental stimuli. No size difference was found in the optic lobes or the central body in either males or females.

**Additional key words:** mushroom body, neuropil, olfactory lobes.

The brain of an insect is the principal associative center of the body. It receives sensory information from a variety of sense organs, processes it and controls all functions of the organism, including complex forms of behavior. Several regions of the brain differing in morphology and function are recognized and referred to as neuropils (Fig. 1). Neuropils are the centers of the regions and are formed by a complex of densely packed nerve fibers. The neurons, which compose a region, lie at its periphery. On histological sections of the brain neuropils appear as much denser, darker than the rest of the brain areas.

The neuropils of particular significance in the processing of information in insect brains are the mushroom bodies and antennal lobes. Mushroom bodies receive signals from different sense organs and experiments on *Drosophila* (Heisenberg et al. 1985, Han et al. 1992) and *Apis* (Erber et al. 1980, Menzel et al. 1974, Hammer & Menzel 1998) suggest that they are implicated in olfactory memory formation. They are composed of three types of cells: cells that direct sig-

nals to the mushroom bodies, cells that deliver signals from the mushroom bodies to other parts of the nervous system, and the intrinsic cells (Kenyon cells) that connect the first two types between themselves. The Kenyon cells occupy the area around the mushroom body neuropil.

All information from the organs of smell (olfactory organs) is received in another brain region: antennal lobes, which are critically important in the delivery of olfactory information to the mushroom bodies. Antennal lobes are composed of a series of neuropils-olfactory glomeruli, which receive and process olfactory signals from the antennae.

Insect species with complex and flexible behavior possess well-developed mushroom bodies and antennal lobes, and larger insects have larger brains and more complex histological brain structure and generally exhibit greater complexity of behavior (Goossen 1949, Bernstein & Bernstein 1969). The largest mushroom bodies (relative to the rest of the brain) are found in social Hymenoptera. The morphological plas-



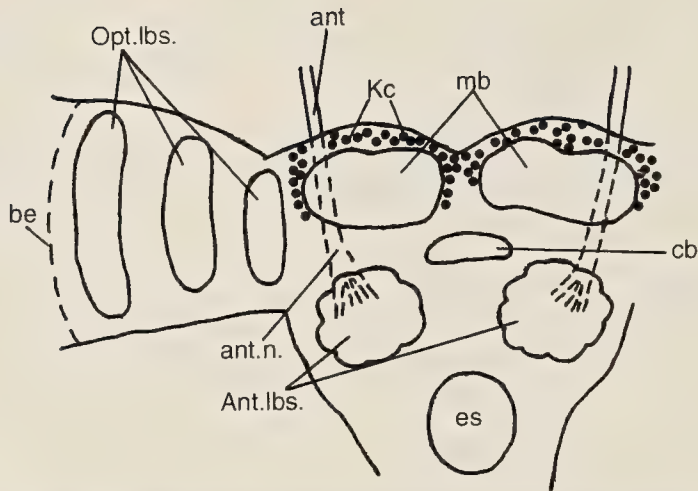


FIG. 1. Diagram of the butterfly brain showing the most important neuropils. **Opt.lbs.**—optic lobes, **Ant.lbs.**—antennal lobes, **mb**—mushroom bodies, **Kc**—Kenyon cells, **cb**—central body, **be**—back of the eye, **ant.n.**—antennal nerve, **ant.**—antenna, **es**—esophagus.

tivity of these brain structures has been demonstrated in bees (Withers et al. 1993, Winnington et al. 1996, Robinson 1998) and ants (Gronenberg et al. 1996). Mushroom bodies increase in size when these insects begin to perform complex and behaviorally more demanding tasks. Neuropil growth related to behavioral changes has also been observed in non-social insects, such as fruit flies and rove beetles (Bieber & Fuldner 1979, Technau 1984, Heisenberg et al. 1995). This growth was found to represent the further arborization and proliferation of existing brain cells, and not the production of new neurons.

Flexibility of behavior and learning have been demonstrated in different species of Lepidoptera (Swihart & Swihart 1970, Papaj 1986, Weiss 1995, 1997, Hartlieb 1996, Fan et al. 1997). Butterflies and moths have well-developed mushroom bodies (Ali 1974, Sivinsky 1989), and large antennal lobes (Matsumoto & Hildebrand 1981). Both olfactory and visual learning have been described in *Agraulis vanillae* (Weiss 1995, Kroutov et al. 1999).

Here we studied brain morphology in two groups of *Agraulis*. One group comprised butterflies collected in nature ("experienced" group) and the other group was reared and maintained in the laboratory in isolation from normal environmental stimuli ("naïve" group). We investigated the hypotheses that the sizes of brain structures involved in information processing and learning vary according to the individual experience of butterflies, and that such structures should be larger in butterflies exposed to various environmental stimuli than in butterflies deprived of those.

#### MATERIALS AND METHODS

Adults and larvae of *Agraulis vanillae* were collected in Gainesville, Florida. All butterflies used in experi-

ments were collected during the 3–4 day period of the abundance peak of the species. Larvae were reared in the laboratory on their natural host-plant *Passiflora incarnata* (L.), picked in the same area where the larvae were found. Laboratory reared adults spent 48 hours after eclosion in 25 × 25 × 25 cm screen cages. The laboratory conditions were 25°C, 65% relative humidity, L:D 16:8 h. Butterflies were fed a 25% sugar solution.

For the preparation of the histological specimens butterfly heads were removed and fixed in Bouin's fixative, prepared 24 hours prior to usage, for 2 days. They were then rinsed in 70% ethanol and embedded in paraffin. Heads of 16 reared males, 10 reared females, 17 wild males and 22 wild females were sectioned. The frontal microtome sections were 10 µm thick and were stained with hematoxylin-eosin.

Volumetric analysis was performed with an AIS/C image analysis system (Imaging Research, Inc.) interfaced to a Zeiss Axiophot microscope via a Dage 72 CCD camera. The following areas were measured in selected spaced sections on both sides of the brain: whole brain, antennal lobes, olfactory glomeruli, optic lobes, central body, mushroom body calyces, and the regions occupied by Kenyon cells. When areas were measured, this was done without awareness of the group to which that individual belonged. The volume of a brain structure was calculated using the formula

$$\text{Vol}_{(\text{object})} = \sum_{i=1}^n A_i \times t \times N$$

where **n** is the number of sections on which measurements were made, **A** is the area of a measured section, **t** is the distance between adjacent sections (e.g., section thickness), and **N** is the number of sections represented by the section **A<sub>i</sub>**. Between 10 and 20 evenly spaced sections were used to determine the volume of each region. This corresponded to 50–100% of all the sections containing each measured structure. The relative volume of each brain structure was calculated as a percentage of the volume of the whole brain.

For statistical analysis of the data a fixed effects linear model (ANOVA) was fit with PROC GLM (SAS v.8). That is, size was modeled as a function of the fixed effects 'brain region', 'butterfly gender' and 'butterfly group' ("experienced", "naïve" and "control"). All relevant assumptions such as constant variance and normality were formally assessed. Due to the large number of multiple Bonferroni comparisons we tested at the 0.01 level of significance throughout.

To exclude the possible effect of age on the changes in *Agraulis* brain, a control group of 10 males and 10 females, reared in the laboratory was kept in cages for 20–25 days after eclosion under the same conditions as described for the experimental group. The heads of



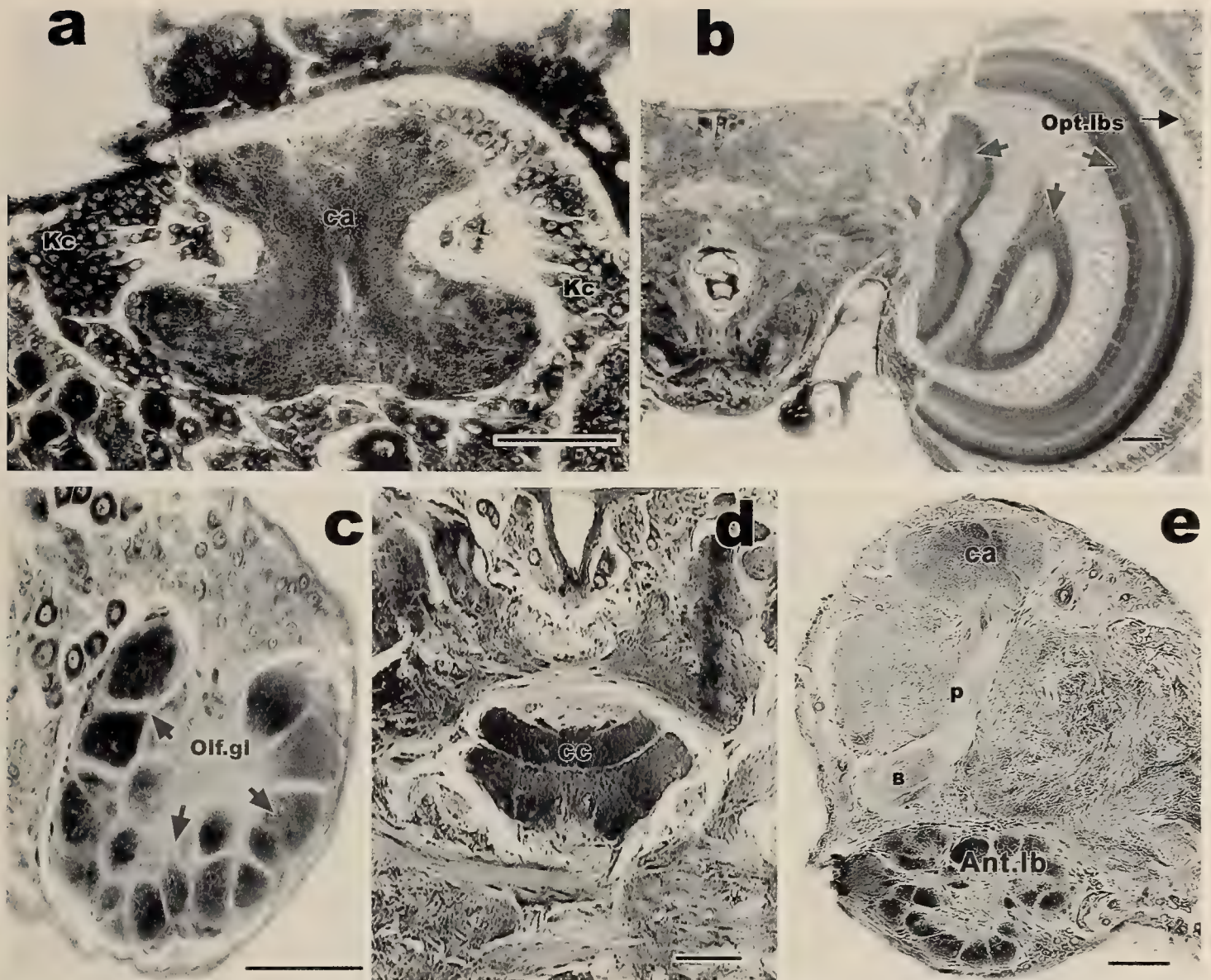


FIG. 2. Sections of the brain of *Agraulis vanillae*. **a**: mushroom body calyx (ca) and Kenyon cells (Kc); **b**: optic lobes (Opt.lbs); **c**: antennal lobe with glomeruli (Olf.gl.); **d**: central body (cc); **e**: mushroom body—calyx (ca), pedunculus (p),  $\beta$ -lobe (B) and antennal lobe (Ant.lb.). **a,b,c,d**—frontal sections, **e**—sagittal section. Scale bars—100  $\mu$ m.

control butterflies were sectioned, sections stained and brains measured as described above.

### RESULTS

Figure 2 shows the sections of the measured brain structures in *Agraulis vanillae*. Most of the regions exhibit clearly defined boundaries. Because of the absence of a clear boundary between the mushroom body's pedunculus and lobes, and the surrounding neuropil, attributable to the staining method chosen for the study, only mushroom body calyces were measured.

Whole brain volume of *Agraulis* showed no significant variation according to group (Fig. 3). There was found to be a significant interaction of gender \*group\* brain region ( $p < 0.0001$ ). Multiple pairwise comparisons revealed the following patterns: "experienced" individuals of both sexes exhibited significantly larger

mushroom bodies and olfactory glomeruli than did "naïve" or "control" individuals (Fig. 4; Table 1). The relative volume of mushroom body calyces in "experienced" butterflies was greater than in "naïve" ones by 36% in males, and by 38% in females. Olfactory glomeruli were larger in "experienced" *Agraulis* by 48% in males, and 24% in females.

The Kenyon cells region and antennal lobes showed mixed outcomes. Within the Kenyon cells region, there were no significant differences in volume among the male groups, but "experienced" females exhibited smaller volumes than did "controls". For the antennal lobes, "experienced" males have larger volumes than do "naïve" males. There were no differences among the female groups. The central body and optic lobe regions exhibited no significant difference for any pairwise comparison.



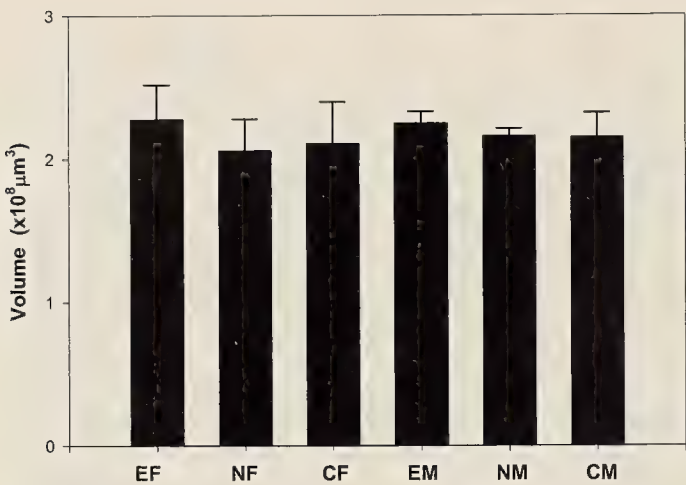


FIG. 3. Whole brain volume in *Agraulis vanillae*. EF—"experienced" females, NF—"naïve" females, CF—"control" females, EM—"experienced" males, NM—"naïve" males, CM—"control" males.

For most brain regions assessed, there was no significant difference between male and female volumes. However, the antennal lobes exhibited the following pattern: "naïve" and "control" females have larger antennal lobes than their male counterparts ( $p < 0.0001$  in each case), but "experienced" females do not differ significantly from "experienced" males.

For all brain regions, the "naïve" and "control" groups exhibited no significant differences in volume, within males or females.

DISCUSSION

The results of our research demonstrate that in *Agraulis* differences in experience are correlated with changes in the volume of several of its brain regions involved in sensory information processing and memory formation. During their adult stage (2–4 weeks), *Agraulis vanillae* butterflies must perform various activities, the success of which can be enhanced by learning. Location of feeding sites with flowers that offer sufficient nectar reward, and recognition of potential danger are of importance to both sexes. Female *Agraulis* need to find suitable host-plants on which to lay eggs. This involves not only recognition of the proper plant amongst a variety of other plants, but also

memory of the location of the host *Passiflora* patch, because butterflies of this species utilize vast habitats and linger at one spot for no longer than is necessary to complete either feeding or egg-laying. Males, in turn, need to locate the host-plant area to encounter females and mate.

Detailed analysis of the captivity conditions and their specific influence on *Agraulis*'s experience, learning and associated morphological changes in its brain was not attempted. However, it seems evident that captive laboratory-reared butterflies would have a greatly reduced range of external stimuli, being deprived of space, visual stimuli, contacts with host-plant, flowers and sex partners. It was also impossible to determine precisely the age of "experienced" butterflies, collected in nature. But because we collected them in a period of 10–14 days after the beginning of their abundance peak, we can estimate all collected butterflies to be of approximately the same age.

Generally, measured brain structures were larger (relative to the volume of the whole brain) in "experienced" butterflies. But no difference in the relative volume of optic lobes and central body was recorded between two groups of *Agraulis*. The most dramatic increases in relative volume occurred in the mushroom bodies and olfactory glomeruli, whereas no size difference in optic lobes between "experienced" and "naïve" butterflies was observed. Therefore, olfactory stimuli may be of primary importance in driving the structural changes in the *Agraulis* brain. Although butterflies reputedly rely heavily on visual stimuli (Swihart 1970, Silberglied 1979, 1984), and *Agraulis* is capable of visual as well as olfactory learning (Weiss 1995), their optic lobes only pass visual information to the central brain, where processing and integration of this information takes place. Therefore such a result is predictable.

The relative decrease in volume of the Kenyon cells region is rather hard to explain. However, because there was no change in the whole brain volume, this region's relative decrease could represent an actual compression of the Kenyon cell clusters by the ex-

TABLE 1. Relative volumes of brain regions as percentage of the whole brain volume in *Agraulis vanillae*. Within each box, different small case letters indicate significant differences, whereas the same letters indicate no difference.

	Mushroom body calyx	Olfactory glomeruli	Kenyon cells region	Antennal lobes	Central body	Optic Lobes
"Experienced" males	2.01 ± 0.08 a	1.45 ± 0.09 a	0.69 ± 0.07 a	3.74 ± 0.35 b	0.61 ± 0.09 a	64.4 ± 3.0 a
"Naïve" males	1.48 ± 0.05 b	0.98 ± 0.05 b	0.75 ± 0.05 a	3.41 ± 0.10 a	0.68 ± 0.04 a	69.7 ± 8.3 a
"Control" males	1.38 ± 0.07 b	0.98 ± 0.09 b	0.72 ± 0.04 a	3.50 ± 0.10 ab	0.66 ± 0.05 a	65.1 ± 2.3 a
"Experienced" females	2.18 ± 0.10 a	1.44 ± 0.08 a	0.56 ± 0.03 a	3.90 ± 0.10 a	0.63 ± 0.07 a	61.8 ± 2.6 a
"Naïve" females	1.58 ± 0.05 b	1.16 ± 0.05 b	0.73 ± 0.05 ab	4.00 ± 0.20 a	0.64 ± 0.03 a	62.4 ± 2.2 a
"Control" females	1.58 ± 0.12 b	1.11 ± 0.04 b	0.84 ± 0.08 b	4.00 ± 0.12 a	0.66 ± 0.02 a	61.1 ± 1.9 a



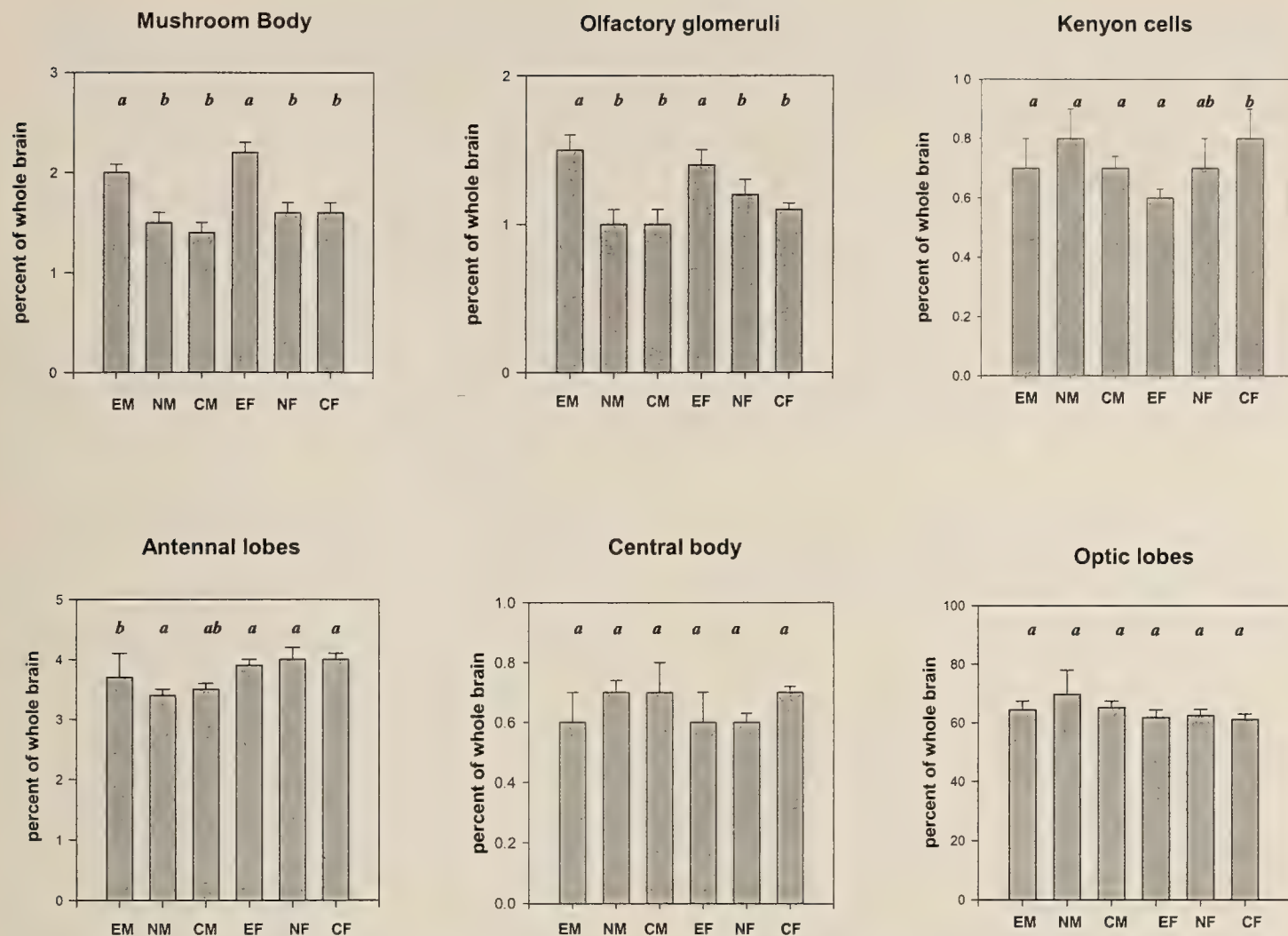


FIG. 4. Relative volumes of brain regions as percentage of the whole brain volume in *Agraulis vanillae*. EM—"experienced" males, NM—"naïve" males, CM—"control" males. EF—"experienced" females, NF—"naïve" females, CF—"control" females. Different small case letters indicate significant differences, whereas the same letters indicate no difference for each sex.

panding mushroom body calyces. This problem could be addressed by more detailed experimental analysis, for example assessment of cell packing density.

The data presented here are similar in many ways to those of studies in other species of insects, which measured the size differences in brain regions caused by different experience and behavioral repertoire. As in the present study, an increase in relative volume of mushroom bodies, and decrease in relative volume of the Kenyon cells region were reported for ants (Gronenberg et al. 1996) and bees (Withers et al. 1993). Also, there was no increase in the relative volume of the optic lobes in either of these insects. Olfactory glomerular volume was found to differ between 1-day-old and nurse bees (larger in nurses), but the increase was not maintained in foragers. For rove beetles mushroom body volume increase and no changes in optic lobe volume were recorded (Bieber & Fuldner 1979).

The sexual dimorphism found in the reorganization of some brain structures in *Agraulis*, namely the dif-

ference in olfactory glomeruli volume between "naïve" and "experienced" males being twice as great as that in females, can perhaps be explained by the differences in behavior of males and females. Females need to locate host-plants and determine their suitability for oviposition, and males need to search for females and recognize proper chemical cues from suitable partners. Thus, each sex may rely on different environmental stimuli. The change in the intensity of these stimuli may effect butterflies of different sexes differently, and cause the observed dissimilarity in the brain reconstruction. This dimorphism corresponds with our earlier findings in *Agraulis* learning (Kroutov et al. 1999), where different learning capability was recorded for the two sexes.

Measurements in the control group show that morphological changes in the brain of *Agraulis vanillae* are not age-related, but experience-related, since the relative volumes of the studied brain structures in 2-day ("naïve") and 20–25-day ("control") butterflies were not significantly different. These changes occur in only



a few brain compartments that are noted for their role in information processing and learning in insects. This further supports the hypothesis that growth of these brain regions is related to learning experience and behavioral complexity of a butterfly.

Further experiments involving the manipulation of various elements of the environment may lead to a better understanding of the exact relation between particular types of information, how they are processed, and changes they cause in the brain of *Agraulis vanillae*. It would be especially interesting to analyze the specific effects of various environmental "deprivations" and, inverted, the effect of additional stimuli on the changes in *Agraulis*' brain structures.

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## PHYLOGENETIC ANALYSIS AND REVIEW OF *PANACEA* AND *BATESIA* BUTTERFLIES (NYMPHALIDAE)

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**ABSTRACT.** Phylogenetic analysis of 53 morphological characters for five species of *Panacea* and *Batesia hypochlora* supports the separation of the two genera and showed that the monotypic genus *Batesia* is basal to *Panacea*. Male genitalia were uniform within *Panacea* and characters informative for phylogeny reconstruction were restricted to wing coloration. Illustrations of adults and genitalia, a brief diagnosis, and distributions are provided for each species.

**Additional key words:** *prola*, *procilla*, *regina*, *divalis*, *bleuzeni*, *chalcothea*, *lysimache*, *bella*, *hypochlora*, *Caryodendron*, Euphorbiaceae.

By possessing distasteful wings or body fluids, brightly colored butterflies are generally avoided by many vertebrate predators in nature. This phenomenon is particularly well known in various genera of Nymphalidae (e.g., *Acraea*, *Heliconius*, many Danainae and Ithomiinae), Papilionidae (e.g., *Battus*, *Parides*) and Pieridae (e.g., *Mylothris*, *Delias*, *Appias*, *Perrhybris*, *Itaballia*) among others (see Poulton 1908, Sywnnerton 1919, Carpenter 1942, Fisher 1958, Chai 1986). Nevertheless, a great many of these same butterflies are eagerly sought after and prized by a different group of predators, human collectors. Although collector value may provide a metric of how garishly colored a particular butterfly might be, it is often a poor measure of how well we understand that species. Therefore, when considering biological or evolutionary understanding of particular butterflies, it is likely that drab ones are equally as well known as those that are brightly colored. Although well represented in museum collections, and available as virtual specimens on the internet, nymphalid butterflies in the genera *Batesia* Felder and Felder, 1862 and *Panacea* Godman and Salvin, 1883 are good examples of this phenomenon.

The Neotropical genus *Batesia* occurs from central Colombia to eastern Ecuador, southeast Peru, western Brazil, and likely into northeast Bolivia; effectively an upper Amazonian distribution. On the other hand, members of *Panacea* are found from Costa Rica south across Venezuela and the Guianas, throughout the Amazon basin, and into Bolivia.

Both *Batesia* and *Panacea* were originally described as monotypic genera, but only *Batesia* with its single species, *hypochlora* Felder and Felder, 1862 has remained so. The history of *Panacea* is somewhat convoluted. *Panacea prola* (Doubleday, 1848) was initially designated the type species of *Pandora* Doubleday,

1848—a name used previously for different insect genera by at least seven different authors, and thus, an invalid homonym (see Hemming 1967). In an attempt to settle this quandary, Kirby (1871) transferred all species of *Pandora* to *Batesia*. Godman and Salvin (1883), however, felt that all species formerly in *Pandora* warranted separation from *Batesia*, and erected the genus *Panacea* to accommodate them—thus providing a panacea to the *Pandora* problem. Eight species have been described in *Panacea*—*P. prola*; *P. procilla* (Hewitson, 1852); *P. regina* (Bates, 1864); *P. divalis* (Bates, 1868); *P. chalcothea* (Bates, 1868); *P. lysimache* Godman and Salvin, 1883; *P. bleuzeni* Plantrou and Attal, 1986; and *P. bella* D'Abbrera, 1987, not all that are currently regarded as valid species (see synonymies below).

The vicissitudes of nomenclature aside, nearly all natural history studies suggest that *Batesia* and *Panacea* are distinct, but closely related genera. At present they are classified in the Biblidini along with *Hamadryas*, *Ectima*, *Eunica*, *Myscelia*, *Dynamine*, *Colobura* and other genera (Godman & Salvin 1883, Seitz 1916, Ackery 1984, Harvey 1991).

Recent observations indicate that *Batesia* and *Panacea* share *Caryodendron* spp. (Euphorbiaceae) as host plants, and that their immature stages are very similar (DeVries et al. 1999). The correspondence of immature biology, classification, and the fact that these genera have never been assessed using cladistic methods led us to ask whether *B. hypochlora* was separate from *Panacea*, or if it represented a derived species within *Panacea*. Accordingly, this study tests both hypotheses through phylogenetic analysis of five species of *Panacea* plus *Batesia hypochlora*. Based on adult morphology we show that *Batesia hypochlora* is basal to *Panacea*, and that together they form a monophyletic group. We then present characters to aid in species identification, and provide notes relevant to future work on their taxonomy and natural history.

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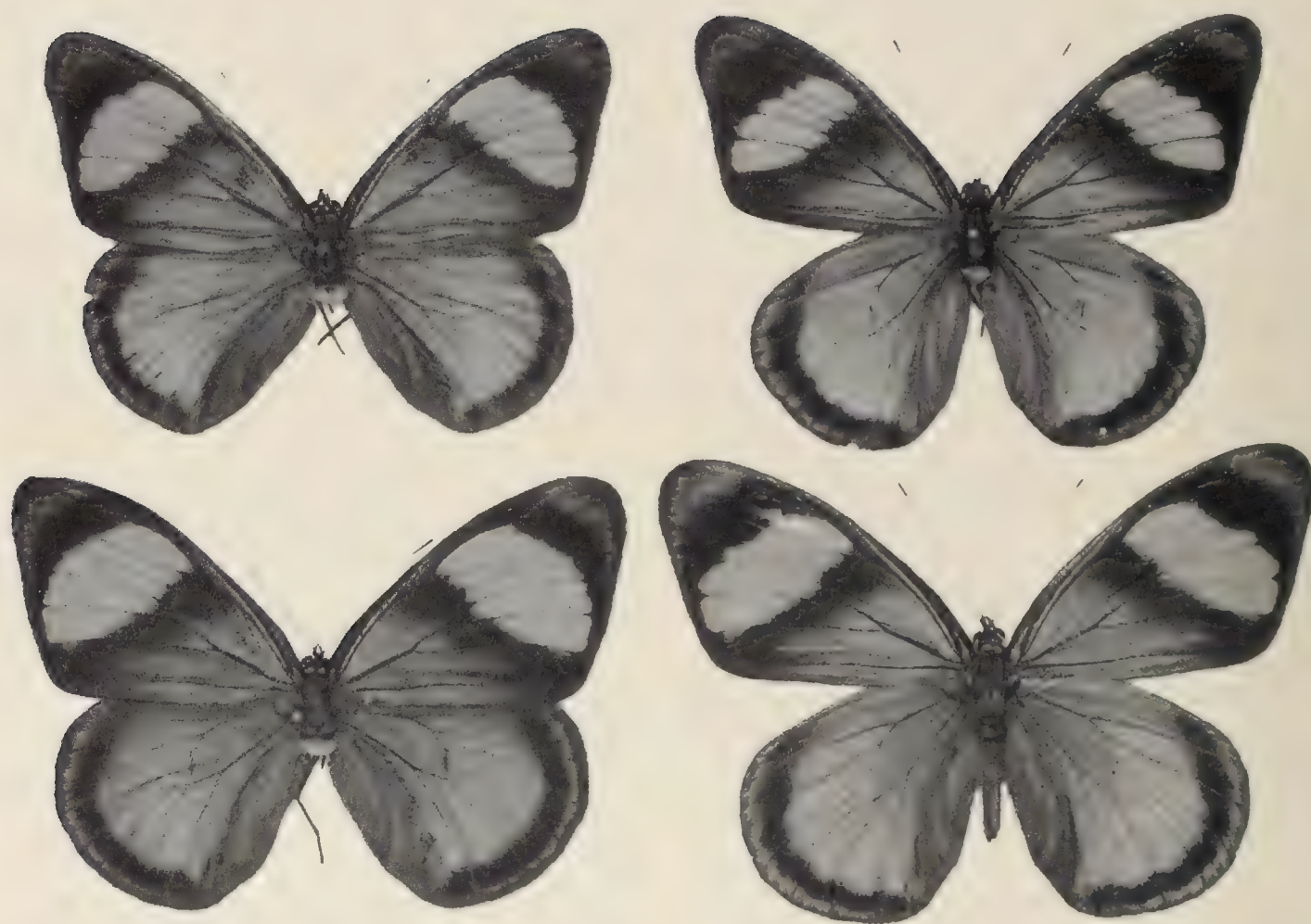


FIG. 1. *Batesia hypochlora*, dorsal. Top row, males; bottom row, females. Left column, Garza Cocha, Ecuador; right column, Rondonia, Brazil.

#### MATERIALS AND METHODS

**Species studied.** Excepting *P. chaltothea* (see identification section below), our phylogenetic analysis included all valid species of *Panacea* (*P. prola*, *P. procilla*, *P. regina*, *P. divalis*, and *P. bleuzeni*) and *Batesia hypochlora* (Figs. 1–10).

To assess intra-specific variation in wing pattern and genitalia, we examined specimens from five distinct localities. Abundant material from a single site in eastern Ecuador (*P. prola*,  $n = 57$ ; *P. divalis*,  $n = 55$ ; *P. regina*,  $n = 43$ ; and *B. hypochlora*,  $n = 24$ ) allowed us to evaluate morphological and phenotypic variation within a single population (see DeVries & Walla 2001 for site description). Whenever possible individuals from different localities were dissected to evaluate morphological variation in the genitalia. Although a small number of specimens were available of *P. procilla* ( $n = 4$ ) and *P. bleuzeni* ( $n = 2$ ), these species are phenotypically distinctive from other *Panacea* and characters could be scored with confidence. For *P. bleuzeni*, one specimen

of each sex was used to score genitalia characters directly, but wing and body characters were scored using the description of Plantrou and Attal (1986), the illustrations in D'Abrera (1987:487, as *P. bella*) and photographs from the private collection of G. Attal. Characters 22 and 23 were scored as "missing" for *P. bleuzeni* due to lack of material. Table 1 lists the examined taxa, number of dissected individuals, and locality data.

We used *Biblis hyperia* (Cramer, 1780) and *Hamadryas arinome* (Lucas, 1853), *H. amphinome* (Linnaeus, 1767), *H. laodamia* (Cramer, 1777), and *H. feronia* (Linnaeus, 1758) as outgroup taxa for phylogenetic analysis. Based on larval and adult morphology, and host plant use (Euphorbiaceae) these taxa are considered closely related to *Batesia* and *Panacea* (Seitz 1916, Ackery 1984, Harvey 1991).

**Preparation of material.** Genitalia were prepared with a standard treatment of 10% potassium hydroxide, examined with a stereomicroscope, and subsequently stored in glycerol. Illustrations are given in Figs. 11–13.

**Characters and terminology.** Our character matrix





FIG. 2. *Batesia hypochlora*, ventral. Left column, Garza Cocha, Ecuador; right column, Rondonia, Brazil.

includes 53 characters (43 binary and 10 multistate), of which 24 were derived from males (23 from genitalia, one from wing coloration), 7 derived from females (6 from genitalia and one from wing coloration), and 22 from both sexes (16 from wing patterns, four from venation, one from forelegs and one from body scales).

Terminology for adult external morphology follows Scoble (1992). Terminology for male and female genitalia follows Klots (1970) except for the use of hypandrium and ramus, which follow the definitions in the glossary of Tuxen (1970) and Jenkins (1986, 1987, 1990). We use hypandrium to mean "a male subgenital plate," and ramus as "lateral or ventro-lateral process of male eighth sternite, directed posteriorly" (see glossary in Tuxen 1970; Jenkins 1983, 1986). In character 10 we follow D'Abrera (1987) where a "complete ocellus" consists of a spot surrounded by a round ring (e.g., *P. procilla*, Fig. 6), and an "incomplete ocellus" is a spot without a round outer ring (e.g., *P. bleuzeni*, Fig. 7).

**Phylogenetic analysis.** We used a heuristic search in PAUP 3.1 (Swofford 1993) with all characters given equal weight, multi-state characters unordered, polymorphic characters treated as exhibiting both states, and the search used a TBR branch swapping routine.

Following analysis, *Biblis hyperia* was used to root the tree. Branch support was estimated by 500 bootstrap replicates, and we used MacClade 3.01 (Maddison & Maddison 1992) to identify character changes along the branches of the tree. The character list and data matrix are in Appendix 1 and 2.

## RESULTS

### Phylogeny

Our analysis indicates that *Panacea* and *Batesia* are monophyletic, sister taxa. The single most parsimonious tree (tree length = 79, CI = 0.82, RI = 0.88) suggests that *Batesia hypochlora* is a sister species to *Panacea*, a relationship supported by four characters (Fig. 14; Table 2, clade 1). We found 11 autapomorphies for *B. hypochlora* (Table 2, clade 2), and nine characters that justify the monophyly of *Panacea* (Table 2, clade 3). Our analysis also showed that all members of *Panacea* are morphologically similar, but they differ strongly from *Batesia hypochlora*.

Among *Panacea* the genital morphology was notably conservative, and characters providing the basis for inferring species relationships were derived mostly from wing morphology. Only one male genital character (hy-





FIG. 3. *Panacea prola*, dorsal and ventral. Top row, left, male; right, female. Bottom row, left male; right, female. All from Garza Cocha, Ecuador.

pandrium, character 28) could be used to distinguish among *Panacea* species. However, as it represents an autapomorphy for *P. divalis*, character 28 was uninformative for establishing phylogenetic relationships within *Panacea*. The grouping of *P. regina*, *P. divalis*, *P. bleuzeni* and *P. procilla* was supported by seven characters, all derived from wing pattern morphology (Table 2, clade 4). One character justified grouping *P. divalis*, *P. bleuzeni* and *P. procilla* (Table 2, clade 5) and a single character grouped *P. bleuzeni* and *P. procilla* (Table 2, clade 6).

#### Identification and Taxonomy

Here we provide synonymies, characters for identification of the study taxa, approximate geographical distributions, and comments on phenotypic variation of the species included in our analysis. For completeness, we also provide taxonomic notes on *P. chalcotea*, although we did not examine this taxon directly.

#### *Batesia* Felder and Felder, 1862

*Batesia* Felder and Felder, 1862. Wien. ent. Monats. 6:112.

#### *Batesia hypochlora* Felder and Felder, 1862 (Figs. 1, 2, 11, 13)

*Batesia hypochlora* Felder and Felder, 1862. Wien. ent. Monats. 6:113

*Batesia hypochlora hypoxantha* Salvin and Godman, 1868. Ann. Mag. Nat. Hist. (4)2:147

*Batesia hypochlora hemichrysa* Salvin and Godman, 1868. Ann. Mag. Nat. Hist. (4)2:147

*Batesia hypochlora chrysocantha* Fruhstorfer, 1915. Soc. ent. 30(12):66

*Batesia hypochlora* f. *intermedia* Michael, 1931. Ent. Zeit. 44(20):309–312

**Species characters.** Forewing dorsal surface dark iridescent blue from basal to submedial areas, a prominent postmedial red band surrounded by black, apex iridescent blue. Hindwing dorsal surface mostly iridescent blue, with a postmedial black band and an iridescent blue marginal band from apex to tornus. Forewing ventral surface dark brown from basal to submedial areas and tornus, postmedial red band surrounded by brown, subapex yellow. Hind-





FIG. 4. *Panacea regina*, dorsal. Top row, male; bottom row, female. All from Garza Cocha, Ecuador.

wing ventral surface chalky yellow with a distinct black postmedial band and yellow marginal band from apex to tornus.

**Distribution.** Western Amazonas, Brazil; Ecuador, Peru (Seitz 1916, D'Abrera 1987, Austin & Emmel 1990, Robbins et al. 1996).

**Variation.** Judging by the named subspecies (see synonymic list) the intensity of yellow on the ventral surface of the HW may vary. However, whether these names are biologically meaningful remains uncertain. We found little variation in our samples from Garza Cocha, Ecuador, although we note that Ecuadorian and Brazilian material differ in the respective width of the forewing subapical band (Fig. 1).

*Panacea* Godman and Salvin, 1883

*Pandora* Doubleday, 1848. Gen. Diurnal Lep. p. 300 Pl. 3 fig 5

*Panacea* Godman and Salvin, 1883. Biol. Centr. Am. pp. 274–275

*Panacea prola* (Doubleday, 1848)  
(Figs. 3, 11, 13)

*Pandora prola* Doubleday, 1848. Gen. Diurnal Lep. p. 300 Pl. 3 fig. 5

*Panacea prola* female f. *dubia* Kretzschmar 1894. Deutsche ent. Zeit. "Iris" 6(2):158–160

*P. prola zaraja* Fruhstorfer, 1912. Ent. Rundschau 29(6):46

*P. prola amazonica* Fruhstorfer, 1915. Soc. ent. 30(12):66

*P. prola prolifica* Fruhstorfer, 1915. Soc. ent. 30(12):66

*P. prola amazonica* f. *bronzina* Bryk, 1953. Arkiv. Fur Zool. 5(1):1–268

**Species characters.** Dorsal surface with broken blue-green iridescent bands. Forewing dorsal surface without a subapical line in both sexes, but some females with a faint greenish-white subapical band. Hindwing dorsal surface without ocelli or blue submarginal line. Hindwing ventral surface bright red, generally without black markings, but sometimes with a faint black submarginal line.





FIG. 5. *Panacea regina*, ventral. Top row, male; bottom row female. All from Garza Cocha, Ecuador.

**Distribution.** Panama, Colombia, Venezuela, Guianas and upper Amazon basin (Seitz 1916, D'Abrera 1987, Emmel & Austin 1990, Otero & Romero 1992, Lamas 1994, Robbins et al. 1996, Neild 1996).

**Variation.** We found wide variation in wing length, but little variation in color pattern in large samples from Garza Cocha, Ecuador. Small individuals appear to be the result of caterpillars feeding on poor quality *Caryodendron* leaves, or those that were semi-starved (pers. obs.).

**Subspecies.** *Panacea prola zaraja*, from Venezuela, Merida; *P. p. amazonica*, from the upper Amazon; *P. p. prolifica*, from Ecuador.

*Panacea regina* (Bates, 1864)

(Figs. 4, 5, 11, 13)

*Pandora regina* Bates, 1864. J. Entom. 2(10):213.

*Panacea regina victrix* Fruhstorfer, 1915. Soc. ent. 30(12):66.

**Species characters.** Dorsal surface with broken blue-green iridescent bands. Forewing ventral surface

with reddish apex and white subapical band but without the distinct red spots outlined by black in discal cell (see *P. divalis*). Hindwing dorsal surface with a blue medial band adorned with incomplete black ocelli that vary in size, and may reach the distal margin of the band; submarginal wavy line sometimes faint. Hindwing ventral surface red with broken submedial to medial transverse black lines, the most distal starting at Sc + Rs and ending at Cu<sub>2</sub>; faint post-medial ocelli in almost all cells; conspicuous black submarginal line. Females often with a short, white longitudinal stripe in ventral hindwing cell M<sub>2</sub>–M<sub>3</sub>, nearly at the center of wing.

**Distribution.** Western and upper Amazon (Ecuador, Peru, Brazil) (Seitz 1916, D'Abrera 1987, Lamas 1994, Robbins et al., 1996).

**Variation.** In Ecuadorian and Brazilian samples we found that the medial ocelli on the dorsal hindwing vary considerably within populations. In females we found the ventral hindwing ocelli were sometimes incomplete.

**Subspecies.** *Panacea regina victrix*, from Ecuador; see also *P. chalcotea* (below).





FIG. 6. *Panacea chalcothea*, male, dorsal and ventral, plus label. This specimen is an apparent syntype (see Identification and Taxonomy). Note: whether *chalcothea* is a subspecies of *P. regina* or a valid species remains to be resolved.

*Panacea chalcothea* (Bates, 1868)  
(Fig. 6)

*Pandora divalis* Bates, 1868. Ent. mon. Mag. 4(44):170.

This somewhat obscure taxon figures importantly in the history of *Panacea*, and its taxonomic status is unresolved. Although we were unable to examine material of *chalcothea* directly, the photo provided by G. Lamas (Fig. 6) may serve as a starting point for identifying this taxon. Here we excerpt correspondence received from G. Lamas that bears directly on the taxonomic interpretation of *Panacea chalcothea*:

“Bates (1868:170) described *chalcothea* based on at least 2 specimens, one female (?) illustrated by Hewitson ([1854], Ill. exot. Butts 1: pl. [42], fig. 4), and thought by the latter to be the female of *procilla*; and one male from “southern Ecuador”. Hewitson’s “female” belonged to the collection of the Entomological Society of London, and that specimen is almost certainly lost, while Bates’ male would have been in his collection, and should have gone to the BMNH through Godman and Salvin. There seems to be no Bates specimen of *chalcothea* from southern Ecuador at the BMNH. However, there is a male specimen from Bates’ collection, labeled *chalcothea* by Bates himself, but from “N Peru”, and I interpret this as a possible syntype of *chalcothea*, agreeing very well with the written description of the male given by Bates in his original paper.

TABLE 1. Number of dissected individuals and locality data. Abbreviations for source collections are: P. J. DeVries (PJD); G. Austin (GTA); G. Attal (GA); Los Angeles County Museum (LACM); Milwaukee Public Museum (MPM).

Taxa	Source of dissected material
<b>Ingroup</b>	
<i>Batesia hypochlora</i>	2 males: Brazil (GTA) 8 males: Ecuador, Sucumbios, Garza Cocha (PJD) 1 female: Brazil (GTA) 1 female: Ecuador, Sucumbios, Garza Cocha (PJD)
<i>Panacea bleuzeni</i>	1 male: French Guyana (GA) 1 female: French Guyana (GA)
<i>Panacea divalis</i>	5 males: Ecuador, Sucumbios, Garza Cocha (PJD) 2 males: Brazil, Rondonia (GTA) 3 females: Ecuador, Sucumbios, Garza Cocha (PJD)
<i>Panacea procilla</i>	2 males: Brazil (n = 1) and Colombia (n = 1) (LACM) 1 male: Colombia (MPM) 1 female: Colombia (MPM)
<i>Panacea prola</i>	5 males: Ecuador, Sucumbios, Garza Cocha (PJD) 3 females: Ecuador, Sucumbios, Garza Cocha (PJD)
<i>Panacea regina</i>	5 males: Ecuador, Sucumbios, Garza Cocha (PJD) 3 females: Ecuador, Sucumbios, Garza Cocha (PJD)
<b>Outgroups</b>	
<i>Biblis hyperia</i>	1 male: Ecuador, Sucumbios, Garza Cocha (PJD) 1 female: Ecuador, Sucumbios, Garza Cocha (PJD)
<i>Hamadryas amphinome</i>	1 male: Ecuador, Sucumbios, Garza Cocha (PJD) 1 female: Ecuador, Sucumbios, Garza Cocha (PJD)
<i>Hamadryas arinome</i>	1 male: Ecuador, Sucumbios, Garza Cocha (PJD) 1 female: Ecuador, Sucumbios, Garza Cocha (PJD)
<i>Hamadryas feronia</i>	1 male: Ecuador, Sucumbios, Garza Cocha (PJD) 1 female: Ecuador, Sucumbios, Garza Cocha (PJD)
<i>Hamadryas laodamia</i>	1 male: Ecuador, Sucumbios, Garza Cocha (PJD) 1 female: Ecuador, Sucumbios, Garza Cocha (PJD)

Bates may well have confused “S Ecuador” with “N Peru”. Anyway, that specimen from “N Peru” most probably came from Amazonas department in Peru. . . . Now, [it] seems to me that *chalcothea* (based on Bates’ o.d. and the syntype referred to above) is . . . very probably a subspecies of *regina*, or could even be a full species. For the time being, I’m calling those 2 specimens as *Panacea regina chalcothea*, though I wouldn’t be too surprised if they were to represent a high altitude species distributed from Colombia to N Peru (if Hewitson’s “New Granada” locality for his specimen is correct, which is quite doubtful).”





FIG. 7. *Panacea divalis*, dorsal. Left column, males; right column, females. Top row, Rondonia, Brazil; middle and bottom rows, Garza Cocha, Ecuador. Note variation in medial bands and submarginal ocelli.

**Distribution.** Apparently Western Amazonas (Ecuador, Peru) and Colombia (?).

*Panacea divalis* (Bates, 1868)  
(Figs. 7, 8, 12, 13)

*Pandora divalis* Bates, 1868. Ent. mon. Mag. 4(44):171.  
*Panacea procilla divalis* Seitz, 1916. Die Gross Schmetterlinge der Erde p. 537.

**Species characters.** Dorsal surface with broken iridescent blue-green bands. Forewing ventral sur-



TABLE 2. Characters justifying the groupings of species and genera. MacClade 3.01 was used to map character changes on the most parsimonious tree. Characters indicated in bold type were unique to the group they support (independent of reversals).

Clade 1. <i>Panacea</i> and <i>Batesia</i>	
(2:0)	Fringe of scales in forewing and hindwing outer margin solid dark color
(16:0)	Ventral surface of hindwing with black submarginal line that is discrete in anal area and more diffuse toward costal area
(24:0)	Thorax: ventral portion completely covered with red-orange scales
(27:1)	In lateral view: Hypandrium without anterior rod-like projections
Clade 2. <i>Batesia hypochlora</i>	
(8:2)	Males: Ventral surface of forewing apex dark, with a yellow band
(19:0)	Forewing venation: M <sub>1</sub> arched toward anal margin
(25:0)	Hypandrium: narrow, plate like, with obvious constriction near the middle of its long axis
(29:0)	In lateral view, anterior portion of tegumen extremely projected
(30:1)	Uncus tip in lateral view sharply hooked
(32:1)	Uncus short
(33:0)	In lateral/ dorso-lateral view, base of uncus with obvious large dorsal ridges
(34:1)	In lateral view, tip of uncus not reaching or extending beyond tip of valva
(37:0)	Distal portion of gnathos small and projected ventrally
(38:0)	In ventral view, distal portion of gnathos with a rounded invagination
(43:1)	Distal portion of valva with small bare chitinous tip
(53:0)	Antrum mostly membranous
Clade 3. <i>Panacea</i>	
(4:1)	Forewing postmedial band expressed dorsally only
(5:1)	In dorsal view, forewing subapical white band reduced
(7:0)	Ventral surface of forewing with white subapical band
(10:0)	Ventral surface of hindwing largely colored red-orange, with or without purplish sheen
(17:0)	Ventral surface of hindwing with dark line imposed upon cross-vein m <sub>2</sub> –m <sub>3</sub> (at distal edge of discal cell)
(23:0)	Foreleg with white scales laterally
(42:0)	Distal portion of valva curving ventrally
(44:0)	In lateral view, basal portion of valva with large conspicuous ventrally produced rounded projection
(46:1)	In lateral view, distal portion of saccus straight to slightly projected upward
Clade 4. <i>Panacea procilla</i> , <i>Panacea bleuzeni</i> , <i>Panacea divalis</i> and <i>Panacea regina</i>	
(8:0)	Males: Ventral surface of forewing apex uniformly dirty red-orange
(11:0)	Ventral surface of hindwing with prominent dark line across basal half of cell Sc + R <sub>1</sub>
(12:0)	Ventral surface of hindwing with prominent dark line across discal cell
(13:0)	Ventral surface of hindwing discal cell with two black dots in basal half
(14:0)	Ventral surface of hindwing with nearly continuous line through medial area that crosses cells Sc + R <sub>1</sub> , Rs, M <sub>1</sub> , M <sub>2</sub> , M <sub>3</sub> , Cu <sub>1</sub> and Cu <sub>2</sub>
(15:1)	Ventral surface of hindwing with dark line not contiguous and line in cell Cu <sub>2</sub> more apical than line in cell Cu <sub>1</sub>
(18:0)	Female: ventral surface of hindwing with white patch of scales in medial area of cell M <sub>2</sub>
Clade 5. <i>Panacea procilla</i> , <i>Panacea bleuzeni</i> and <i>Panacea divalis</i>	
(5:0)	In dorsal view, forewing subapical white band well developed
(6:0)	In ventral view, forewing discal cell with two red-orange spots, one at base and one at mid-length
Clade 6. <i>Panacea procilla</i> and <i>Panacea bleuzeni</i>	
(3: 0)	In dorsal view, male forewing with oblique, diffuse black band encroaching on postmedial blue/green band.

face with reddish apex, white subapical band and distinct red spots outlined by black in discal cell (see *P. regina*). Hindwing ventral surface brownish red with a faint purple sheen; broken transversal black medial lines, the most distal starting at Sc + Rs and ending at 1A; postmedial ocelli (black “rings”) on almost all cells; conspicuous black submarginal line. Females with a short, white longitudinal stripe in ventral hindwing cell M<sub>2</sub>–M<sub>3</sub>, nearly at the center of wing. Incomplete ocelli on dorsal surface of hindwing vary in size, and may be absent in some specimens.

**Distribution.** Upper Amazon (Seitz 1916), Colombia to Peru (D’Abrera 1987) and western Brazil (Emmel & Austin 1990).

**Variation.** In males the dorsal hindwing marginal

band varies among samples from Brazil and Ecuador; the dorsal hindwing ocelli vary from diffuse to sharp; a short, ventral longitudinal stripe may occur in ventral hindwing cell M<sub>2</sub>–M<sub>3</sub>. In females the white, ventral longitudinal stripe in hindwing cell M<sub>2</sub>–M<sub>3</sub> may be diffuse or faintly expanded into the two cells above.

**Subspecies.** None.

*Panacea procilla* (Hewitson, 1852)  
(Figs. 9, 12, 13)

*Pandora procilla* Hewitson, 1852. Exot. Butt. 1.  
*Panacea lysimache* Godman and Salvin 1883. Biol. Centr. Americana p. 275.  
*P. procilla ocana* Fruhstorfer, 1912. Ent. Rundschau 29(6):46.





FIG. 8. *Panacea divalis*, ventral. Left column, males; right column, females. Top row, Rondonia, Brazil; middle and bottom rows, Garza Cocha, Ecuador. Note variation in white stripe centered in cell  $M_2-M_3$ .

*P. procilla salacia* Fruhstorfer, 1915. Soc. Ent. 30(12):66.

*P. procilla lysimache* Seitz, 1916. Die Gross Schmetterlinge der Erde p. 537.

*P. procilla* var. *marmorensis* Hall, 1917. Entomologist 50(651):171-174.

**Species characters.** Dorsal surface with broken blue-green iridescent bands. Forewing ventral surface with distinct red outlined by black in discal cell, reddish apex and white subapical band. Hindwing ventral surface brownish red with a faint purple





FIG. 9. *Panacea procilla*, dorsal and ventral. Left column, male; right column, female. Specimens from Cali, Colombia.

sheen; broken transverse medial black lines, the most distal starting at Sc + Rs and ending at 1A; complete postmedial ocelli on almost all cells, those on cells  $M_3$ - $Cu_1$  and  $Cu_1$ - $Cu_2$  with iridescent pupil; conspicuous black submarginal line. Dorsal surface of hindwing with a medial blue band adorned with black ocelli; conspicuous submarginal wavy line. Females with white medial band on ventral forewing, and also with a white band on ventral hindwing from cell Sc +  $R_1$ -Rs to  $M_2$ - $M_3$ , sometimes interrupted on  $M_1$ - $M_2$ .

**Distribution.** Costa Rica south to Colombia and throughout the upper Amazon basin and the Guianas (Kretzschmar 1894, Apolinar 1926).

**Variation.** We observed some males that have a short, white longitudinal stripe in ventral hindwing cell  $M_2$ - $M_3$ , nearly at the center of wing—a pattern similar to females of *P. regina* and *P. divalis*.

**Subspecies.** *Panacea procilla procilla*, western Venezuela (Neild 1996), *P. p. ocana*, from lower Magdalena River, Colombia (Seitz 1916, D'Abrera 1987); *P. p. salacia*, from Colombia (Seitz 1916, D'Abrera

1987); *P. p. lysimache* from Volcan Chiriqui, Panama, Finca la Selva, Costa Rica (DeVries 1987, 1989).

*Panacea bleuzeni* Plantrou and Attal, 1986  
(Figs. 10, 12, 13)

*Panacea bleuzeni* Plantrou and Attal, 1986. Bull. Société Sciences Nat. 50:23.

*Panacea bella* D'Abrera, 1987. Butterflies of the Neotropical Region, part III: p. 487, **new synonym**

**Species characters.** Dorsal surface distinctively blue or blue-green. Dorsal surface of hindwing with a blue medial band adorned with large black ocelli; wavy iridescent submarginal line conspicuous. Ventral forewing with distinct red outlined by black in discal cell, reddish apex and white subapical band (similar to *procilla*). Ventral hindwing with transverse medial black line continuous from cell Sc + Rs to vein 1A; ocelli faint. Females with white marking extending distally along black medial line from cell Sc + Rs to  $Cu_2$ -1A.





FIG. 10. *Panacea bleuzeni*, female, dorsal and ventral. This figure is reproduced through the kind permission of B. d'Abrera [Butterflies of the Neotropical Region, part III:487]. It is the type of *Panacea bella* D'Abrera, 1987.

**Distribution.** Apparently endemic to the Guianas (Plantrou & Attal 1986). However, its overlapping range with *procilla* and close relationship to it (Table 2, clade 6) suggest the possibility that this taxon may be a subspecies of *procilla*. This point needs critical evaluation.

**Synonymic notes.** Examination of the collection of the BMNH by A. Neild (pers. com.) revealed that the single female holotype of *P. bella* is also a paratype of *P. bleuzeni*. This, therefore, indicates that *P. bella* and *P. bleuzeni* represent a single species with *bella* as a junior synonym of *bleuzeni*. Comparing the illustration of the type specimen of *bella* (in D'Abrera 1987) with photographs of male and female *P. bleuzeni* provided by G. Attal confirms this assessment.

#### DISCUSSION

Our analysis showed that *Batesia* and *Panacea* form a monophyletic group, with *B. hypochlora* basal to *Panacea*. Therefore, despite similarities in early stage morphology and host plant use, we reject the hypothesis that *B. hypochlora* is a derived species from within *Panacea*. Our study confirms the maintenance of *Batesia* and *Panacea* as separate taxa (e.g., Godman & Salvin 1883, Seitz 1916), and serves as a framework for future systematic work on both genera. We note that, without examining material firsthand, *P. chalcotea* is presumed to be the sister taxon of *P. regina*. However, the phylogenetic position of *chalcotea* requires confirmation, including its taxonomic rank.

Insect genitalia are widely used for phylogenetic



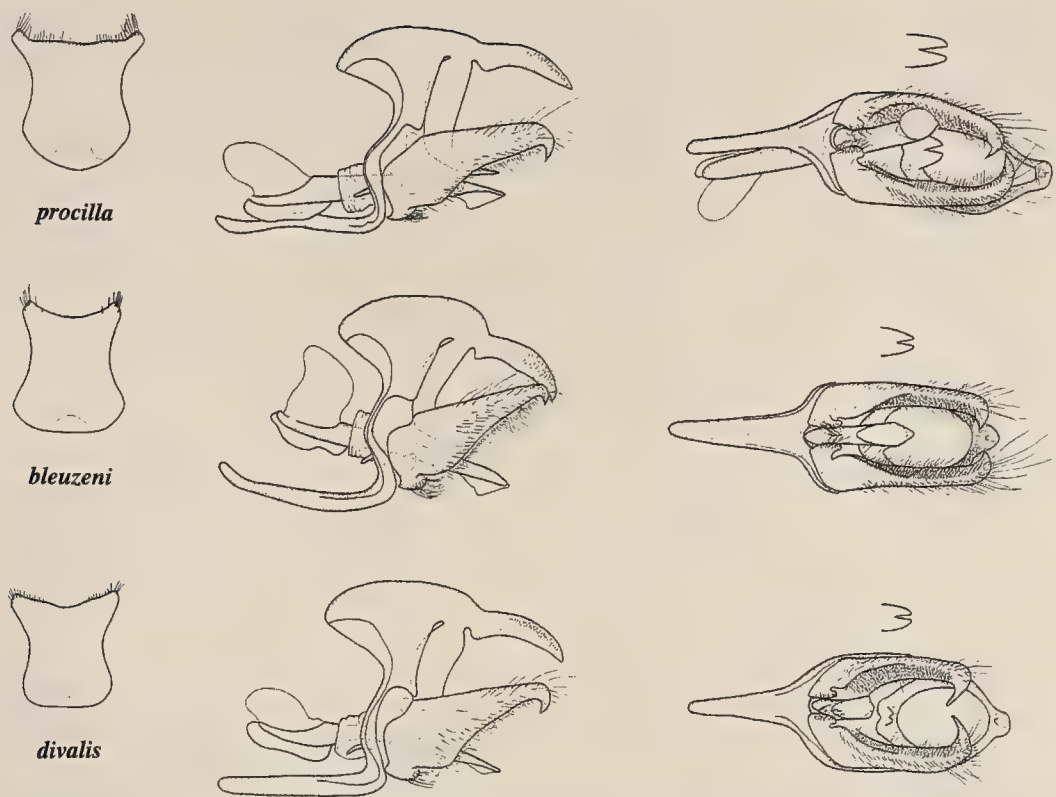


FIG. 11. Male genitalia: hypandrium, lateral view, ventral view (inset: tip of gnathos in ventral view). *Panacea procilla*, *P. bleuzeni*, and *P. divalis*.

reconstruction and delimiting species boundaries because their morphology may diverge rapidly, and therefore provide informative characters (Eberhard 1985, Porter & Shapiro 1990, Arnqvist 1998). In

*Panacea*, however, we found that the genitalia were highly conserved and provided no informative characters for phylogeny reconstruction, or discrimination among species. Rather, the species-level rela-

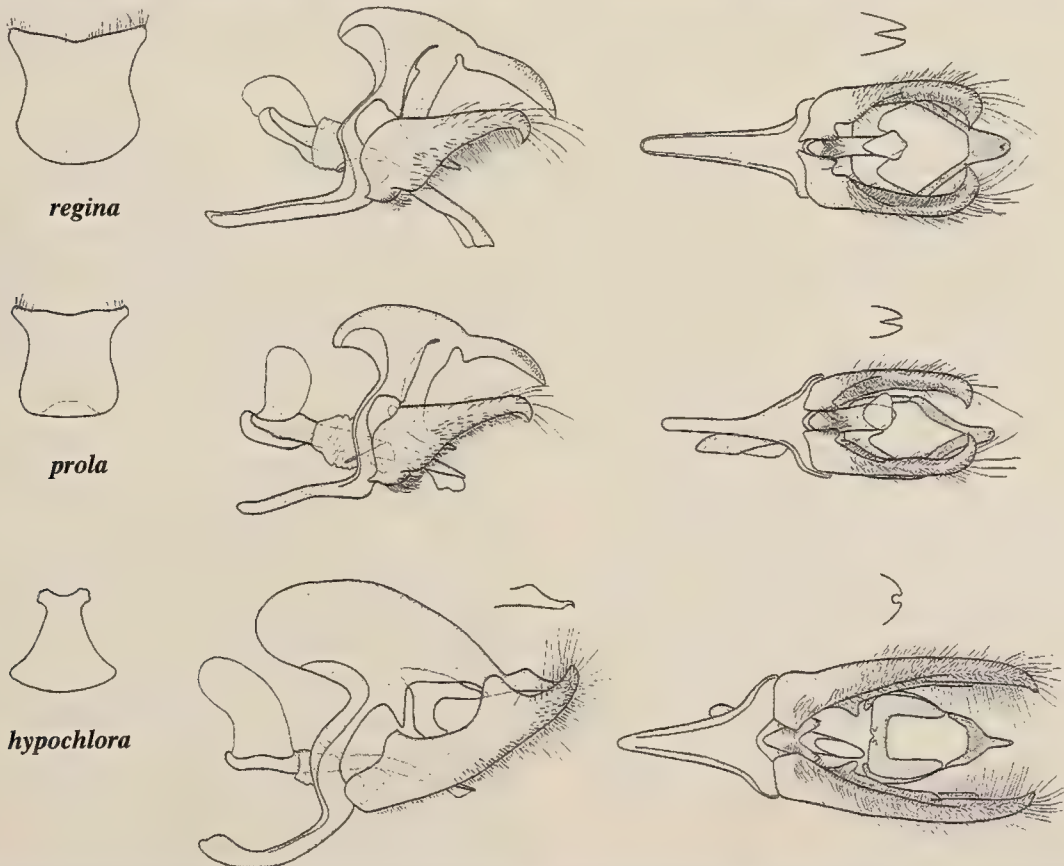


FIG. 12. Male genitalia: hypandrium, lateral view (inset: uncus in lateral view), ventral view (inset: tip of gnathos in ventral view). *Panacea regina*, *P. prola*, and *Batesia hypochlora*.



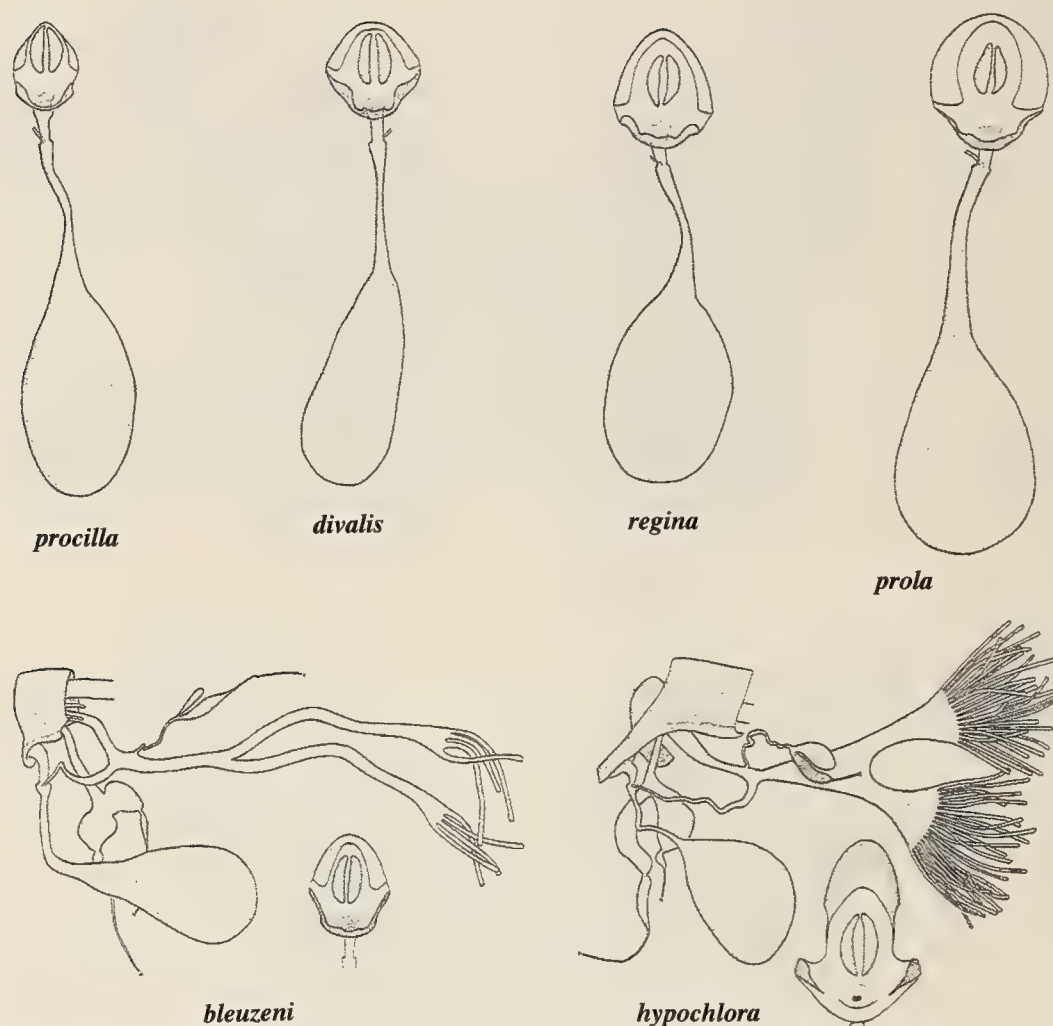


FIG. 13. Female genitalia: ventral view, *Panacea procilla*, *P. divalis*, *P. regina*, and *P. prola*. Lateral view: *P. bleuzeni*, and *Batesia hypochlora* (insets: genitalia in ventral view). Note differences in the number of ovarioles between *P. bleuzeni* and *B. hypochlora*.

tionships proposed here were derived solely from characters of wing pattern (Fig. 14, Table 2). Our study suggests that the most distinctly colored species, *P. prola*, is basal to other congeners, with remaining species groupings justified by differences in wing patterns.

The distinctive behavior and coloration make *Panacea* easily recognizable in the field. However, in large samples from one Ecuadorian site we found considerable intraspecific variation in both genital morphology and wing color patterns. This concurs with Seitz (1916) who noted that in some *Panacea* species within population phenotypic variation may be greater than among population variation, indicating that there may be transitions among species with respect to color pattern. With the possible exception of *P. prola*, such phenotypic variation precludes the notion that sympatric *Panacea* species can be positively identified in nature without capturing them.

*Batesia* and *Panacea* are obvious and often abundant elements of many Neotropical butterfly faunas

and museum collections. Nevertheless, some taxa are rare in collections, and this study points to several questions that will require a full taxonomic revision to resolve, particularly regarding the status of *P. chla-cothea* and *P. bleuzeni*. Although potentially useful tools for conservation ecology, little has been reported on the natural history *Batesia* and *Panacea*. What we do know is that adults of both genera show significant flight height preference in some lowland rainforests, and that trees in the genus *Caryodendron* are larval hostplants (see DeVries 1989, Montoya 1991, DeVries et al. 1999, DeVries & Walla 2001). We do not know if all taxa exhibit vertical stratification, if these butterflies use other hostplant genera, or if some species are warningly colored (e.g., *P. prola*, *Batesia*) that represent models in mimicry complexes. We believe that field studies, in concert with phylogenetic analyses of *Hamadryas*, *Ectima*, *Eunica*, and related genera is the next step toward understanding the evolution of *Batesia* and *Panacea*, and the diversification of the Biblidini.



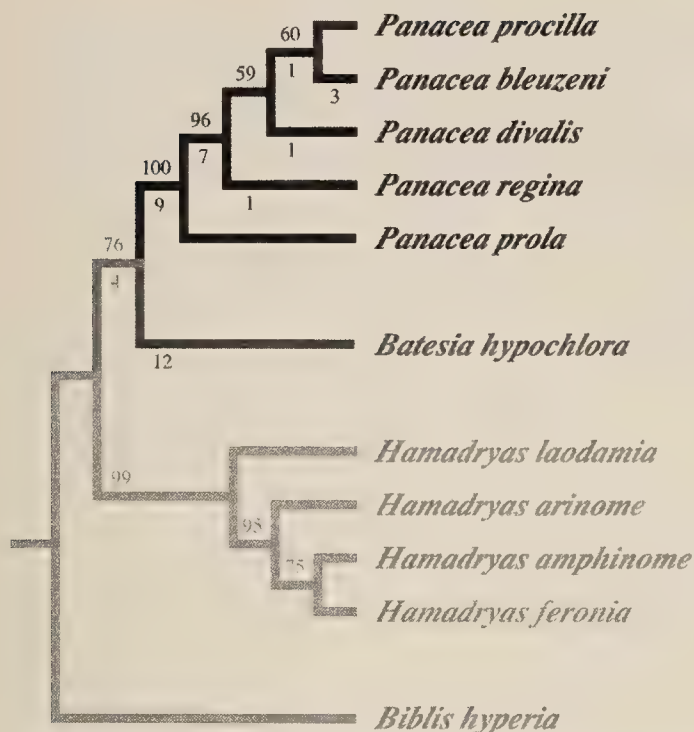


FIG. 14. Single most parsimonious tree obtained from the analysis of 53 characters for 11 species (tree length = 79, CI = 0.82, RI = 0.88). Numbers above and below tree branches represent bootstrap values and the number of unambiguous changes respectively.

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APPENDIX 1. Character list used in the phylogenetic analysis. Relevant figures are noted, and comments are included when needed. Definitions are in the Characters and Terminology section.

### Wing Characters:

1. Forewing outer margin: concave (0), straight (1), convex (2).
2. Fringe of scales in the outer margin of wings: solid dark color (0), dark interspersed with white sections (1).
3. In dorsal view, male forewing with oblique, diffuse black band encroaching on postmedial blue-green band (0); devoid of such a pattern (1). Note: *P. bleuzeni* was scored using original description, illustration in D'Abrera and photos provided by G. Attal.
4. Forewing postmedial band expressed dorsally and ventrally (0); expressed dorsally only (1); absent or reduced (2). Note: *H. laodamia* and *P. procilla* were polymorphic for this character because of differences between the sexes.
5. In dorsal view, forewing subapical white band well developed (0); reduced (1); absent (2).
6. In ventral view, red-orange spots on forewing discal cell: two spots present, one at base and one at mid-length (0), one spot present, at mid-length (1), absent (2).
7. Ventral surface of forewing with white subapical band (0); devoid of such pattern (1).
8. Males, ventral surface of forewing apex: uniformly dirty red-orange (0); dark, same color as medial area (1); dark, with a yellow band (2).
9. Dorsal and ventral sides of hindwing consistently with four complete ocelli (0); dorsal side of hindwing with five incomplete ocelli (lacking outer ring) and clearly separated from any black lines (1); ventral side of hindwing with four to six complete ocelli (2); devoid of such patterns (3). Note: To understand the variation in this character a large number of specimens were examined, and we found no exceptions to the patterns described here (see Methods, Species studied).
10. Ventral surface of hindwing largely colored red-orange, with or without purplish sheen (0); devoid of such a pattern (1). Note: although the presence of a purplish sheen has been used to separate *P. procilla* and *P. divalis*, we found this character to be present in both these species and variable within each of them.
11. Ventral surface of hindwing with prominent dark line across basal half of cell Sc + R<sub>1</sub> (0); devoid of such a pattern (1).
12. Ventral surface of hindwing with prominent dark line across discal cell (0); devoid of such a pattern (1).
13. Ventral surface of hindwing: discal cell with two black dots in basal half (0); devoid of such a pattern (1). Note: of the 57 *P. prola* specimens examined, three had two dots, 22 had one dot, and 32 lacked dots; in *P. divalis*, four of the 53 specimens had dots merged into a single marking.
14. Ventral surface of hindwing with: nearly continuous line through medial area that crosses cells Sc + R<sub>1</sub>, Rs, M<sub>1</sub>, M<sub>2</sub>, M<sub>3</sub>, Cu<sub>1</sub> and Cu<sub>2</sub> (0); devoid of such a pattern (1).
15. Ventral surface of hindwing with: dark line in cell Cu<sub>2</sub> and cell Cu<sub>1</sub> contiguous (0); dark line not contiguous and line in cell Cu<sub>2</sub> more apical than line in cell Cu<sub>1</sub> (1); dark line not contiguous and line in cell Cu<sub>2</sub> more basal than cell Cu<sub>1</sub> (2); dark line absent from cell Cu<sub>2</sub> (3).
16. Ventral surface of hindwing with black submarginal line which is discrete in anal area and becomes more diffuse toward costal area (0); devoid of such a pattern (1). Note: *P. bleuzeni* was scored using the illustrations in D'Abrera (1987) and photos from the collection of G. Attal.
17. Ventral surface of hindwing with dark line imposed upon cross-vein m<sub>2</sub>–m<sub>3</sub> (at distal edge of discal cell) (0), devoid of such a dark line (1). Note: in *P. prola*, three of 53 specimens lacked the dark line.
18. Female, ventral surface of hindwing with white patch of scales in medial area of cell M<sub>2</sub> (0); devoid of white patch (1). Note: two males of *P. procilla* had similar white patch. In *P. divalis* one of 12 lacked the patch, and in *P. regina* two of 14 lacked the patch.
19. Forewing venation: M<sub>1</sub> arched toward anal margin (0); devoid of such a pattern (1).
20. Forewing venation: M<sub>2</sub> arched toward anal margin (0); devoid of such a pattern (1).
21. Forewing cross-vein m<sub>2</sub>–m<sub>3</sub> + cu<sub>1</sub>: joins M<sub>3</sub> + Cu<sub>1</sub> at or distal to the fork M<sub>3</sub> and Cu<sub>1</sub> (0); proximally to the fork M<sub>3</sub> and Cu<sub>1</sub> (1); absent (2). Note: M<sub>3</sub> + Cu<sub>1</sub> denotes the combination of vein M<sub>3</sub> and Cu<sub>1</sub> proximal to the fork where they split.
22. Forewing cross-vein r–m<sub>1</sub>, and the base of M<sub>1</sub> and M<sub>2</sub>: inflated (0); not inflated (1).

### Body Characters:

23. Foreleg with white scales laterally (0); devoid of white scales (1).
24. Thorax: ventral portion completely covered with red-orange scales (0); devoid of such a pattern (1).

### Male Genitalia Characters:

25. Hypandrium: narrow, plate like, with obvious constriction near the middle of its long axis (0); broad, curling laterally, without a constriction (1).
26. In lateral view, hypandrium with long ramus projecting posteriorly (0); devoid of projections (1).
27. In lateral view, hypandrium with anterior rod-like projections (0); devoid of such a pattern (1).
28. In lateral view, posterior corner of hypandrium extended into an obvious lobe-like process that projects dorsally (0); less lobe-like and not as projected dorsally (1).
29. In lateral view, anterior portion of tegumen extremely projected (0); devoid of such a pattern (1).
30. In lateral view, uncus tip: pointed (0); sharply hooked (1).



APPENDIX 1. Continued.

31. Uncus: bifid (0); entire (1).
32. Uncus: elongate (0); short (1).
33. In lateral/ dorso-lateral view, base of uncus with obvious large dorsal ridges (0); with small ridges (1); devoid of such a pattern (2).
34. In lateral view, tip of uncus reaching or extending beyond tip of valva (0); devoid of such a pattern (1).
35. Uncus with obvious, long setae dorsally (0); devoid of setae (1).
36. Distal portion of gnathos: completely fused (0); bifid (1).
37. Distal portion of gnathos: small and projected ventrally (0); large and projected posteriorly (1).
38. In ventral view, distal portion of gnathos: with a rounded invagination (0); invaginated in a perfect "V" (1).
39. Valva: with dentate process approximately 2/3 from its base (0); without such a process (1).
40. Process of valva: projecting dorsally (0); projecting medially (1).
41. Process of valva: with setae (0); without setae (1).
42. Distal portion of valva: curving ventrally (0); curving dorsally or straight (1).
43. Distal portion of valva with large bare chitinous tip (0); with small bare chitinous tip (1); devoid of such patterns (2).
44. In lateral view, basal portion of valva: with large conspicuous ventrally produced rounded projection (0); devoid of such a pattern (1).
45. In lateral view, rod-like projections of juxta: large (0); small (1).
46. In lateral view, distal portion of saccus: strongly projected upward (0); straight to slightly projected upward (1).
47. In lateral view, vinculum with obvious dentate process along anterior margin (0); process shaped as a bump, not dentate (1).
<b>Female Genitalia Characters:</b>
48. Signa: present (0); absent (1).
49. Sterigma: present (0); absent (1).
50. Lamella antevaginalis: continuous across ventral surface (0); split (1).
51. Lamella antevaginalis: fused to edge of eighth sternite (0); not fused (1).
52. Ductus seminalis connecting to ductus bursa: very near corpus bursa (0); far from corpus bursa, and near ostium bursa (1).
53. Antrum: heavily sclerotized (0); mostly membranous (1).

APPENDIX 2. Character Matrix.

<b>Ingroup</b>						
<i>Batesia hypochlora</i>	1010221231	1111301101	0110011?01	1101110000	1111001111	111
<i>Panacea prola</i>	0011100130	1111300111	0100111010	101011111?	?000011110	110
<i>Panacea procilla</i>	000(0,1)000000	0000100011	0100111010	101011111?	?000011110	110
<i>Panacea divalis</i>	0011000030	0000100011	0100111110	101011111?	?000011110	110
<i>Panacea regina</i>	0011120020	0000100011	0100111010	101011111?	?000011110	110
<i>Panacea bleuzeni</i>	0002000010	0010000011	??00111010	101011111?	?000011110	110
<b>Outgroups</b>						
<i>Biblis hyperia</i>	2112221131	1111311111	2111110?10	0020101?1?	?101001100	110
<i>Hamadryas laodamia</i>	211(0,2)221131	1111311111	1011100?10	1010011?01	0121100011	000
<i>Hamadryas arinome</i>	1110221131	1111311110	1001100?10	1011011101	0121100011	000
<i>Hamadryas amphinome</i>	11102?1130	1111310110	1001100?10	10?1011101	0121100011	000
<i>Hamadryas feronia</i>	111?211?01	0110210?10	1001100?10	1011011101	0121110011	000



## REVISED IDENTITIES AND NEW SPECIES OF *AETHES* FROM MIDWESTERN NORTH AMERICA (TORTRICIDAE)

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**ABSTRACT.** Ongoing systematic study of Nearctic Tortricidae revealed several historical misidentifications and new species of *Aethes* in the Midwest. We redefine *A. promptana* (Robinson), *A. angulatana* (Robinson), *A. argenteimitana* (Robinson), and *A. atomosana* (Busck); resurrect *A. interruptofasciata* (Robinson); and synonymize *A. labeculana* (Robinson) with the prior *A. argenteimitana*, and *A. sublepidana* (Kearfott) with the prior *A. interruptofasciata*. We describe as new species *A. sexdentata* Sabourin & Miller, *A. razowskii* Sabourin & Miller, *A. westratei* Sabourin & Miller, *A. matheri* Sabourin & Miller, *A. terriae* Sabourin & Miller, *A. baloghi* Sabourin & Metzler, and *A. matthew-cruzi* Sabourin & Vargo. The status of six species previously considered *incertae sedis* is resolved, and the number of recognized Nearctic *Aethes* species is increased from 27 to 34. Conclusions are based on type study as well as on more than 500 pinned specimens and more than 300 genitalia preparations in 29 museums and private collections. A comprehensive definition of *Aethes* also is presented.

**Additional key words:** Tortricinae, Cochylini, taxonomy.

The genus *Aethes* is holarctic, with 27 species previously recognized in North America (Metzler 1999, Pogue 1986, Powell 1983, Razowski 1986, 1994, 1997). The higher category to which *Aethes* belongs has been ranked variously from tribe to family, but a consensus is emerging that the appropriate rank is tribe, namely Cochylini of Tortricinae.

Cochylini are difficult to discriminate and identify because of sibling or cryptic species, variability in maculation and size, and geographic variation. Lack of detailed systematic work, including unstudied types and mixed type series, adds to the confusion surrounding the taxonomy of *Aethes* and its relatives.

In the early 1900's, Busck (1907) and Kearfott (1907a, 1907b) described a number of Cochylini species. Forbes (1923) provided a synopsis of species recorded from New York and neighboring areas. With additional collecting and increased interest in biodiversity, Cochylini have attracted new attention. In a dissertation, Pogue (1986) proposed a new generic classification of Nearctic Cochylini, including *Aethes*, and we draw liberally upon his work, all of which has not been published. He recognized 102 described species in 23 genera, with 8 species *incertae sedis*. Razowski (1997) recently reviewed Canadian species, but did not examine all types. Metzler (1999) described two species in connection with work on Midwestern prairie insects.

Structurally, *Aethes* has one notable synapomorphy: the paired sicklelike structures of the male socii. Otherwise, *Aethes* includes markedly diverse genital structure. A number of structural characters useful for species discrimination are found on or in the aedeagus and associated parts.

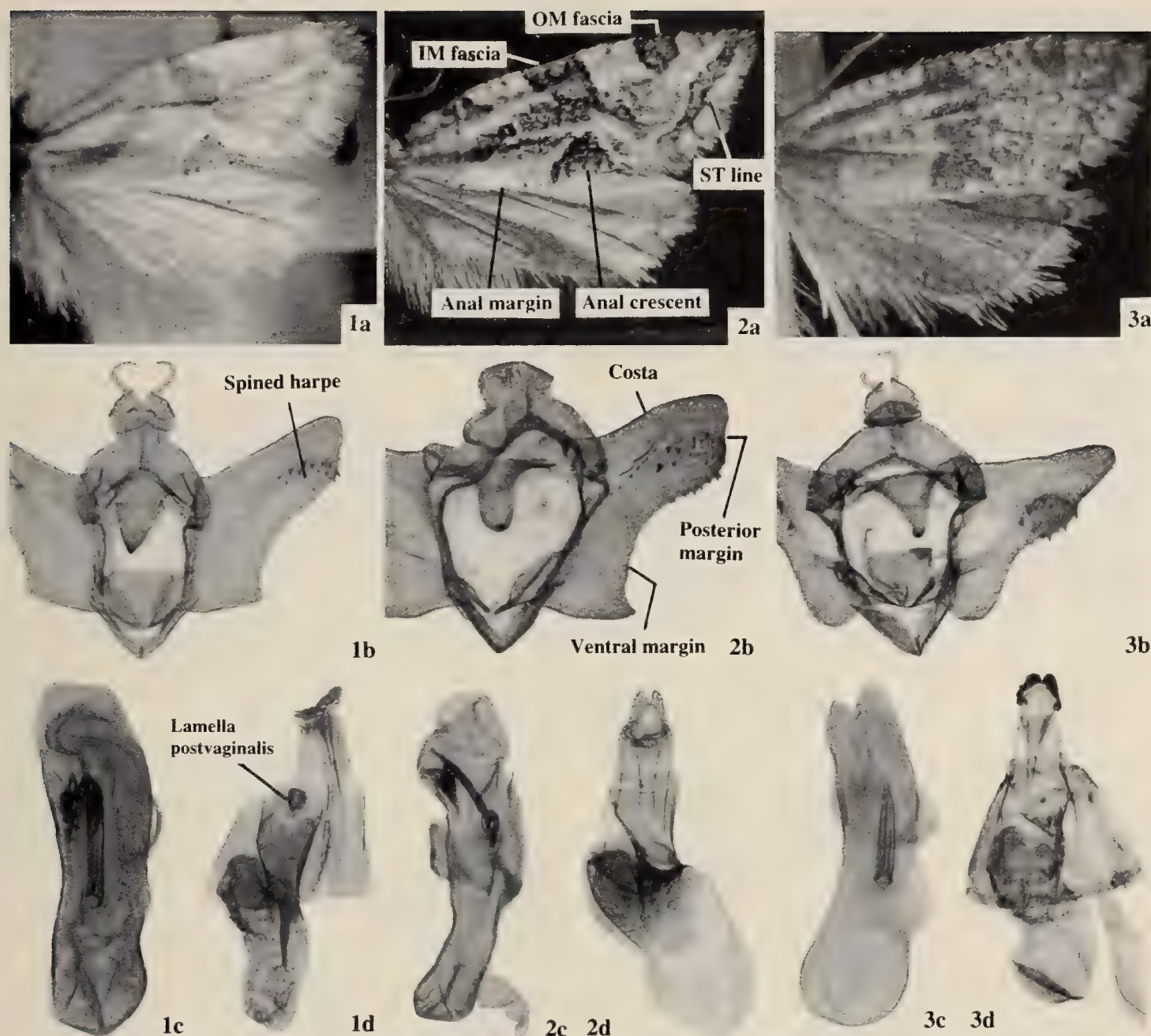
This paper redefines and illustrates five *Aethes* species whose identities have been confused historically. In addition, seven new species are added to the Nearctic fauna. The seven new species raise the number of *Aethes* recognized in North America from 27 to 34.

### MATERIALS AND METHODS

This study is based on more than 500 pinned adults assembled from 29 sources listed at the end of this section. Genitalia of more than 300 specimens were prepared. For the five previously known species treated here, "Specimens examined" sections are shortened to States and Provinces of specimen origin, months of capture, and depositories. Detailed lists of such specimens are available from the authors.

Wing lengths were measured by caliper under magnification to the nearest 0.2 mm. Colors were determined under incandescent light by comparison with the swatches of Smithe (1975).





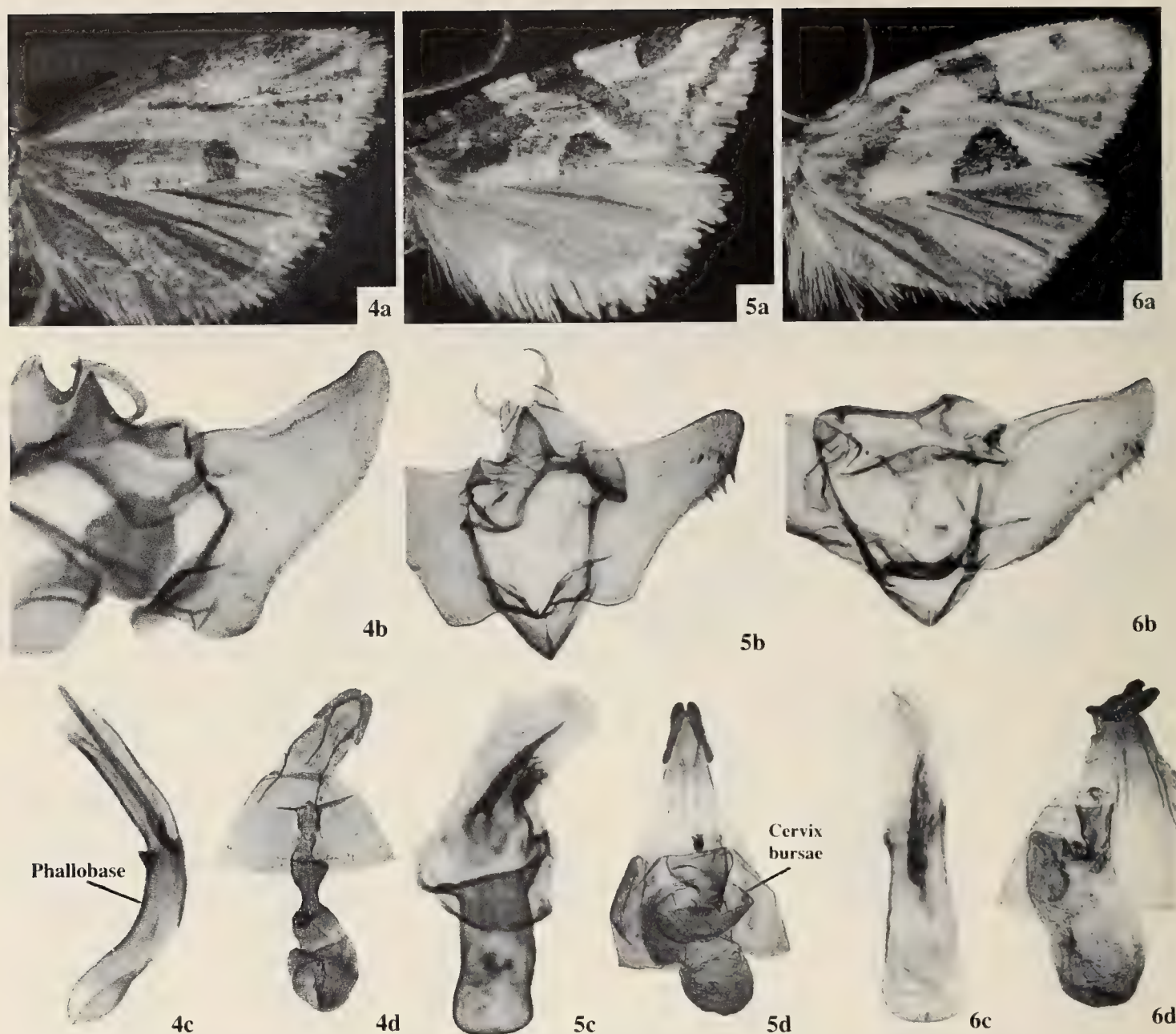
FIGS. 1a-3d. *Aethes* species. 1a. Wings of *A. promptana* lectotype ♂. 1b. Genitalia of *A. promptana* lectotype ♂ (prep. MGP936). 1c. Aedeagus of *A. promptana* lectotype ♂ (prep. MGP936). 1d. Genitalia of *A. promptana* ♀ from Grantsburg, Wisconsin (prep. MS99182). 2a. Wings of *A. angulatana* ♂ from St. Joseph Co., Indiana. 2b. Genitalia of *A. angulatana* ♂ from St. Joseph Co., Indiana (prep. MS00253). 2c. Aedeagus of *A. angulatana* ♂ from St. Joseph Co., Indiana (prep. MS00253). 2d. Genitalia of *A. angulatana* lectotype ♀ (prep. MGP932). 3a. Wings of *A. argenteimitana* ♂ (*A. labeculana* lectotype ♂). 3b. Genitalia of *A. argenteimitana* ♂ (*A. labeculana* lectotype ♂) (prep. MGP934). 3c. Aedeagus of *A. argenteimitana* lectotype ♂ (prep. MGP931). 3d. Genitalia of *A. argenteimitana* ♀ from Grand Isle, Vermont (prep. MS01052).

Genitalia were prepared by placing abdomens in cold 10% KOH for 24–48 hours. After removal from KOH, they were cleaned in distilled water, soaked in 70% isopropyl alcohol, then stained in aqueous Chlorazole Black E (3 minutes for males and 1–2 minutes for females). Following Chlorazole staining, pelts were double-stained with lignin pink and acid fuchsin (males for 3 minutes, females for 1 minute). Pelts were then returned to 70% isopropyl alcohol, and the genitalia removed. The male aedeagus was separated with the juxta remaining attached to it. Genitalia then were placed in 99% isopropyl alcohol for 15 minutes. Fi-

nally, they were stored in glycerine in glass pin vials, or mounted on slides in Canada balsam or Euparal thinned with Cellosolve, and dried at 19°C for five weeks. Vinyl cover-slip props were used on female slides to reduce distortion.

Whole specimens were photographed under tungsten lights with a 35-mm camera attached to a dissecting microscope, except for Fig. 11a which was produced with a Polaroid microscope camera with a fiber optic light source. Genitalia were photographed with a 35-mm Olympus photomicrographic apparatus. All photo images were scanned, after which they were en-





FIGS. 4a–6d. *Aethes* species. 4a. Wings of *A. interruptofasciata* ♂ from Burnett Co., Wisconsin. 4b, Genitalia of *A. interruptofasciata* ♂ from Lk. Katherine, Wisconsin (prep. MS01040). 4c, Aedeagus of *A. interruptofasciata* ♂ from Allegheny Co., Pennsylvania (prep. MS01056). 4d, Genitalia of *A. interruptofasciata* ♀ from Kanawha Co., West Virginia (prep. MS99068). 5a, Wings of *A. sexdentata* paratype ♂ from S. Burlington, Vermont. 5b, Genitalia of *A. sexdentata* holotype ♂ from Grand Isle, Vermont (prep. MS10046). 5c, Aedeagus of *A. sexdentata* holotype ♂ from Grand Isle, Vermont (prep. MS10046). 5d, Genitalia of *A. sexdentata* paratype ♀ from Clark Co., Illinois (prep. MS98427). 6a, Wings of *A. razowskii* paratype ♂ from Allegan Co., Michigan. 6b, Genitalia of *A. razowskii* holotype ♂ from Schoolcraft Co., Michigan (prep. MS01050). 6c, Aedeagus of *A. razowskii* paratype ♂ from Winston Co., Alabama (prep. MS99196). 6d, Genitalia of *A. razowskii* paratype ♀ from Winston Co., Alabama (prep. MS99197).

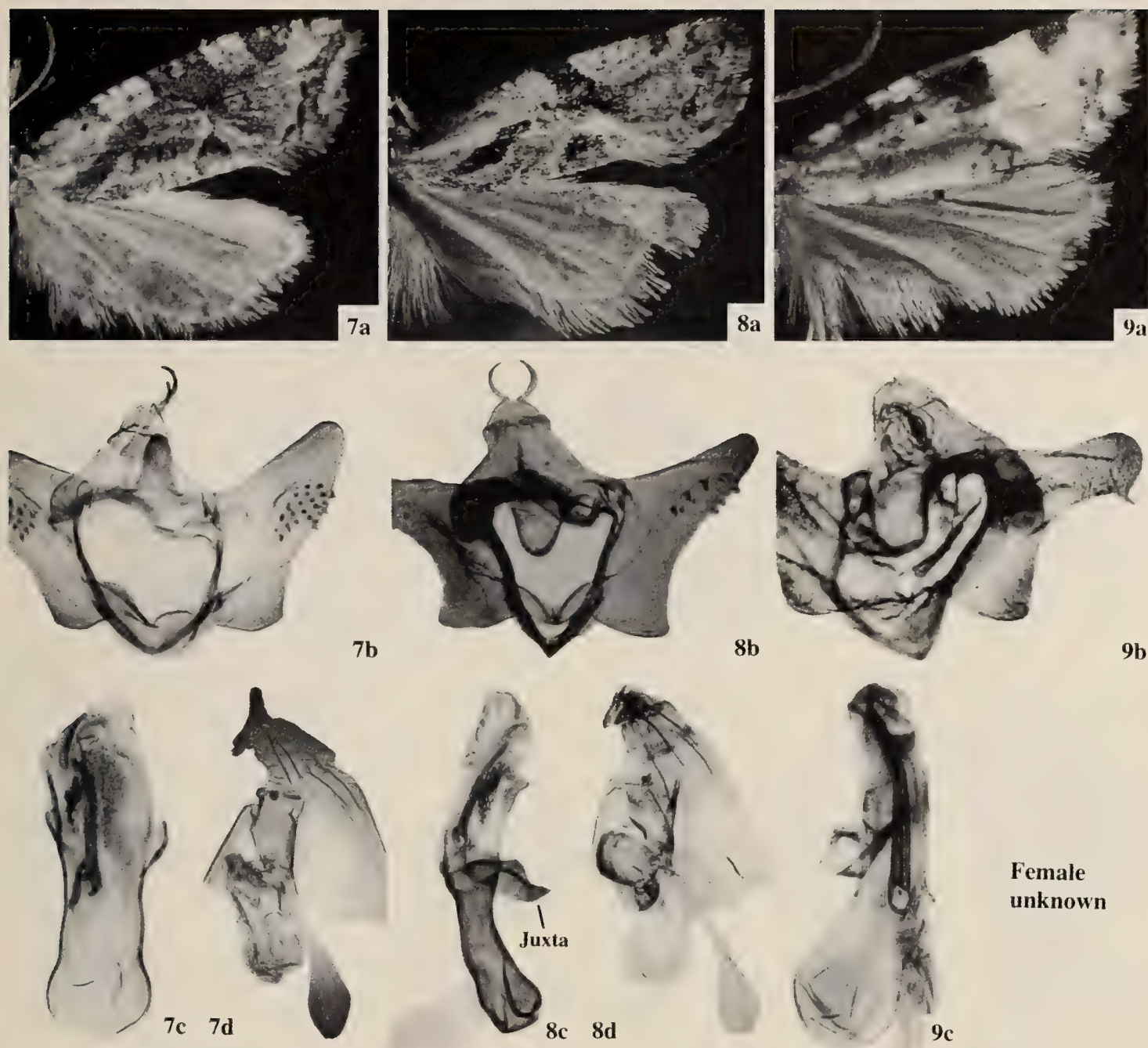
hanced and cropped with Apple Photoflash software, then laser printed.

Abbreviations used are as follows: AL, at light; BL, black light; BLT, black-light trap; FW, forewing; gen. prep., genitalia preparation; HW, hindwing; IG, in glycerine; IM fascia, inner median fascia (antemedian, antemedial, and median of authors); LT, light trap; OM fascia, outer median fascia (postmedian or preapical of authors); n, number of specimens on which a statement is based; ND, no date; ST line, subterminal line; UV, UVL, ultraviolet light. Collection dates are in month/day/year format.

Certain anatomical terms are defined or illustrated or both as follows. Anal margin: the straight portion of the forewing trailing edge (Fig. 2a); anal crescent: mark on anal margin of the forewing (Fig. 2a); harpe: slightly raised spined area on the interior distal half of the valva (Fig. 1b); costa of the valva: dorsal margin of the valva (Fig. 2b); posterior and ventral margins of the valva (Fig. 2b); phallobase: sheath surrounding the base of the aedeagus (Fig. 4c). Illustrations of some other terms are noted on first use in the text.

Collection abbreviations used are: AMNH, American Museum of Natural History, New York, New York;



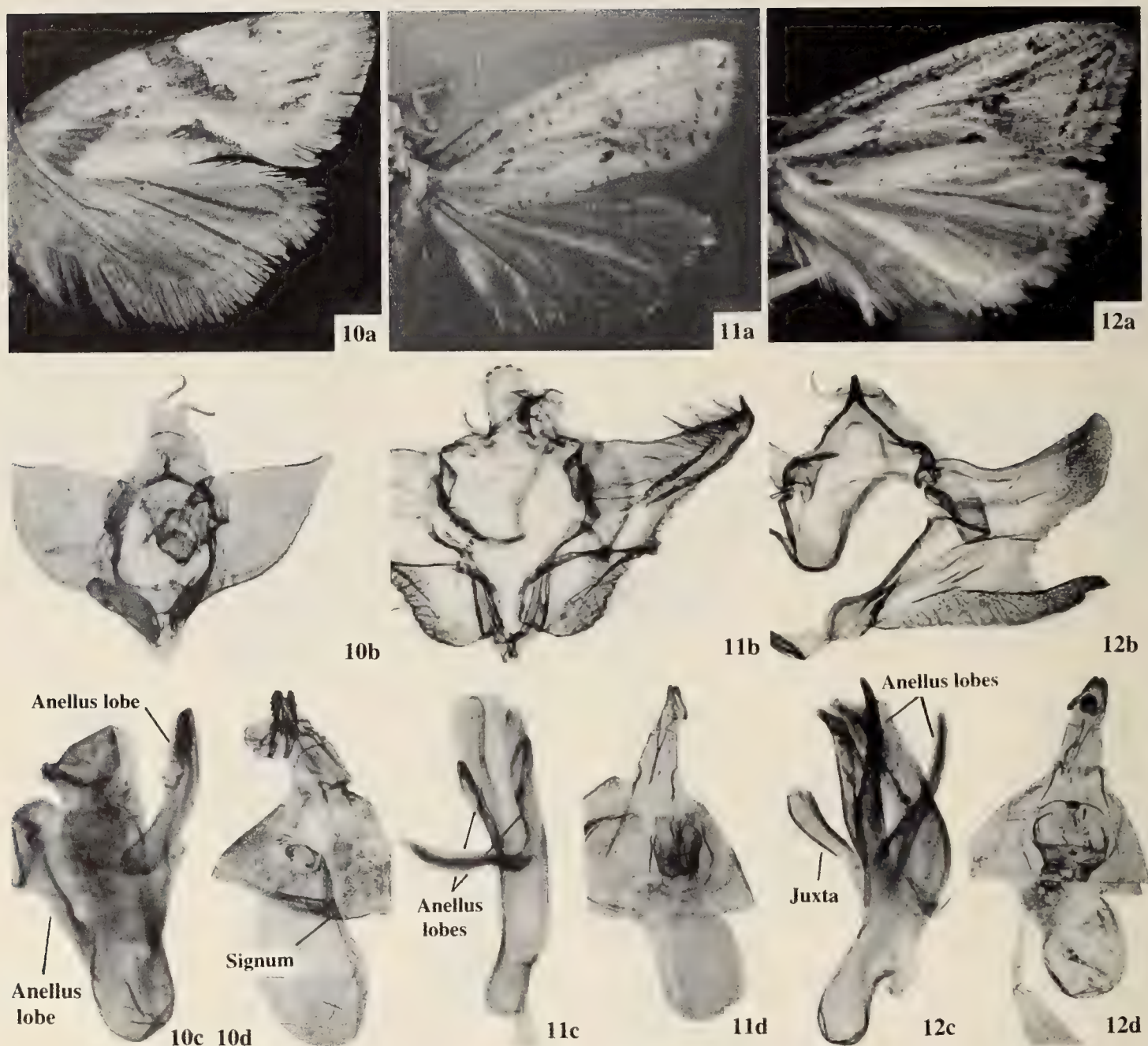


FIGS. 7a-9c. *Aethes* species. 7a, Wings of *A. westratei* paratype ♀ from Cass Co., Michigan. 7b, Genitalia of *A. westratei* paratype ♂ from Cass. Co., Michigan (prep. MS01048). 7c, Aedeagus of *A. westratei* paratype ♂ from Cass. Co., Michigan (prep. MS01039). 7d, Genitalia of *A. westratei* paratype ♀ from Cass Co., Michigan. (prep. MS98146). 8a, Wings of *A. matheri* holotype ♂ from Long Beach, Mississippi. 8b, Genitalia of *A. matheri* paratype ♂ from Hinds Co., Mississippi (prep. MS01082). 8c, Aedeagus of *A. matheri* paratype ♂ from Hinds Co., Mississippi (prep. MS01082). 8d, Genitalia of *A. matheri* paratype ♀ from Harrison Co., Mississippi (prep. MS01132). 9a, Wings of *A. terriae* holotype ♂ from Kalamazoo Co., Michigan. 9b, Genitalia of *A. terriae* paratype ♂ from Cass Co., Michigan (prep. MS01088). 9c, Aedeagus of *A. terriae* paratype ♂ from Cass Co., Michigan (prep. MS01088).

ANSP, Academy of Natural Sciences of Philadelphia, Philadelphia, Pennsylvania; BGS, B. G. Scholtens collection, Charleston, South Carolina; BM, The Natural History Museum, London, England; BMMS, B. Mather collection, Mississippi Entomological Museum, Mississippi State, Mississippi; CMNH, Carnegie Museum of Natural History, Pittsburgh, Pennsylvania; CNC, Canadian National Collection of Insects, Ottawa, Ontario; EME, Essig Museum of Entomology, University of California, Berkeley; FMNH, Field Mu-

seum of Natural History, Chicago, Illinois; GJB, G. J. Balogh collection, Portage, Michigan; FMPS, Frost Entomological Museum, Pennsylvania State University, University Park; INHS, Illinois Natural History Survey, Champaign; JDG, J. D. Glaser collection, Baltimore, Maryland; JHW, J. H. Wilterding III collection, East Lansing, Michigan; JRH, J. R. Heitzman collection, Independence, Missouri; JV, J. Vargo collection, Mishawaka, Indiana; MAR, M. A. Roberts collection, Steuben, Maine; MS, M. Sabourin collection,





FIGS. 10a–12d. 10a, Wings of *A. baloghi* holotype ♀ from Yonkers, New York. 10b, Genitalia of *A. baloghi* paratype ♂ from Allegan Co., Michigan (prep. MS01083). 10c, Aedeagus of *A. baloghi* paratype ♂ from Newaygo Co., Michigan (prep. MS01098). 10d, Genitalia of *A. baloghi* paratype ♀ from Whitesbog, New Jersey (prep. MS01077). 11a, Wings of *A. atomosana* ♂ from Kings Co., Nova Scotia. 11b, Genitalia of *A. atomosana* ♂ from Lunenburg Co., Nova Scotia (prep. MS01047). 11c, Aedeagus of *A. atomosana* ♂ from Lunenburg Co., Nova Scotia (prep. MS01047). 11d, Genitalia of *A. atomosana* ♀ from Burnett Co., Wisconsin (prep. MS00653). 12a, Wings of *A. matthewcruzi* holotype ♂ from Roseau Co., Minnesota. 12b, Genitalia of *A. matthewcruzi* holotype ♂ from Roseau Co., Minnesota (prep. MS00167). 12c, Aedeagus of *A. matthewcruzi* holotype ♂ from Roseau Co., Minnesota (prep. MS00167). 12d, Genitalia of *A. matthewcruzi* paratype ♀ from Burnett Co., Wisconsin (prep. MS00342).

Grantsburg Wisconsin; MSG, M. S. Griggs collection, Grand Isle, Vermont; MSUC, Michigan State University, East Lansing; NSPM, Nova Scotia Museum, Halifax; RL, R. Letsinger collection, Sarcoxie, Missouri; UMMZ, University of Michigan, Ann Arbor; UMRM, University of Missouri, Columbia; UMSP, University of Minnesota Entomology Museum, St. Paul; USNM, National Museum of Natural History, Washington, D. C.; UWEM, University of Wisconsin, Madison; WPW, W. P. Westrate collection, Cassopolis, Michigan; YPM,

Yale University Peabody Museum of Natural History, New Haven, Connecticut; ZMUH, Zoological Museum, University of Helsinki, Finland.

#### Genus *Aethes* Billberg, 1820

Type species: *Pyrallis smeathmanniana* Fabricius, 1781, designated by Fernald (1908).

The characterization that follows is based mainly on North American species.

No significant external sexual dimorphism. Speci-



mens cannot reliably be sexed by number of frenular bristles; males have one bristle, females one or two.

**Head.** Proboscis conspicuous; ocelli present; scales of labial palpus expanded ventrally beyond third segment, inner side usually of FW ground color, outer side of FW marking colors. **Thorax.** Short dorsal tuft usually present; lateral tufts of metanotum consisting of flattened hairs or elongate scales. **FW** longer than wide, lacking costal fold, costa slightly curved, termen slanted toward body, apex acute or obtuse. All veins usually free,  $R_1$  and  $Cu_2$  originating, respectively, from middle and distal  $\frac{1}{3}$  of discal cell; origins of  $R_2$ ,  $R_3$ ,  $R_4$ ,  $M_2$ , and  $M_3$  usually closer to veins following them than to veins preceding them,  $R_5$  extending to costa before apex, origins of  $R_5$  and  $M_1$  usually closer to veins preceding them than to those following them,  $M_3$  and  $Cu_1$  adjacent or connate,  $CuP$  absent, the last probably constituting a cochyline synapomorphy (Pogue 1986); a vestigial chorda present in some species. Variably developed subcostal and cubital retinacula retain female frenular bristles. Ground color usually pale with markings darker; basal fascia usually thin, sometimes broad, or absent; median fascia reduced, represented by inner and outer parts, the inner one sometimes complete from costa to anal margin (Fig. 2a), sometimes divided into costal and anal parts, the anal part forming a crescent along the anal margin; outer fascia complete in some species, in others represented by a small spot along costa; discal spot usually present, consisting of scales at the distal end of the discal cell beyond the inner median fascia; ST line (Fig. 2a) occasionally present. **HW** costal fold usually lacking, veins  $R_s$  and  $M_1$  stalked; origins of  $M_3$  and  $Cu_1$  well separated. **Abdomen.** Proximal apodeme of sternum 2 a short stub or cone. Anterolateral process longer than proximal apodeme. Venulae of sternum 2 long, contrasting. **Male genitalia:** Aedeagus variable in length and width, vesica may have one large cornutus accompanied by a small bundle of cornuti, or cornuti may be absent altogether. Anellus lobes (Figs. 10c, 11c, 12c) sometimes present. Juxta (Figs. 8c, 12c) typically a simple subquadrate or subrectangular plate attached to apex of phallobase, caulis absent. Valva broad, posterior margin (Fig. 2b) variable, some species with dentiform spines on the harpe (Fig. 1b) in a pattern that makes the distal portion of the valva resemble a shark snout. Sacculus varying in length and shape. Uncus usually indiscernible, socii with dual apical sicklelike structures. Apex of vinculum arms variable in size, free, or fused by a thin membrane. **Female genitalia:** Papillae anales elongate, narrow, lightly sclerotized. Anterior and posterior apophyses slender, as long as or longer than papillae

anales. Sterigma variable, sometimes reduced; without bilateral sclerotized bands connecting sterigma to anterior apophyses; lamella postvaginalis (Fig. 1d) usually present as a medial process or plate. Antrum robust to reduced. Ductus bursae highly variable, ranging from absent to present to coalesced with corpus bursae such as to be almost unrecognizable. Cervix bursae (Fig. 5d) sometimes present. Supplementary bursa (accessory bursa of authors) present, usually originating dorsally at base of antrum. Ductus seminalis originating from ductus-, cervix-, or corpus bursae, usually not from supplementary bursa. Signum (Fig. 10d) usually absent, but if present represented by sclerotized vestiges of ductus bursae or broad sclerotized plates.

Yasuda (1972) mentions peculiar bristles on tarsal segments 1–4 of the hind leg as being of taxonomic importance. These are short, dark spines occurring on the ventral surface of tarsomeres, usually singly or in rows at joints. In *Aethes* species treated here, the bristle groups on apical edges of eutarsal and distitarsal segments occur in a 3:3:3:3 pattern.

*Aethes promptana* (Robinson)

(Fig. 1a–d)

*Conchylis promptana* Robinson (1869:286, pl. 8, fig. 80) (Lectotype ♂ designated here, type # 7440, #77, no data, FW 6.0 mm long, gen. prep. MGP936 [Fig. 1b, c], in ANSP). Fernald (1882:25), Handfield et al. (1997:44).

*Phalonia promptana*; Dyar et al. (1903:487), Forbes (1923:508, in part), McDunnough (1939:60), Brower (1983:50, in part).

*Phtheochroa promptana*; Poole & Gentili (1996:876).

*Aethes promptana*; Razowski (1997:124, figs. 150–152, in part).

**Male and female exterior.** Frons cream colored, vertex, notum, and tegulum buff-yellow; labial palpus 3× longer than horizontal eye diameter. Thoracic tuft inconspicuous. Hind leg buff except for the shorter tibial spurs which are darker. **FW** (Fig. 1a) 5.7–7.9 mm long ( $n = 21$ ). Ground color cream, markings buff-yellow with scattered brown scales; fasciae not bordered by darker scales; costa and anal margin outlined with short striae; basal fascia extending to costa, also slightly into discal cell at midpoint; IM fascia (Fig. 2a) extending into cell, coalescing with discal spot; anal crescent and OM fascia (Fig. 2a) present; ST line (Fig. 2a) extending to apex; fringe of ground color. **HW** drab gray.

**Male genitalia** (Fig. 1b, c) ( $n = 7$ ). Costa of valva straight, posterior margin broad, rounded, numerous dentiform spines on harpe; sacculus short, ventral



margin straight. Median process of transtilla broad, tri-angulate, with a toothlike point. Aedeagus thick, vesica bearing one large, thick cornutus, a bundle of smaller cornuti, and a distal crescent-shaped sclerite. Anellus lobes absent.

**Female genitalia** (Fig. 1d) ( $n = 9$ ). Lamella post-vaginalis a large triangular medial process; anterior apophyses longer than posterior; antrum robust, elongate, tapering on anterior half. Cervix bursae sinistrocudad of corpus bursae when viewed as in Fig. 1d.

**Diagnosis.** Superficially resembling *A. patricia* Metzler, but the FW markings of *A. promptana* are buff rather than red. Also, the posterior margin of the valva, the sacculus, median process of transtilla, and aedeagus (Fig. 1b, c) are all broader than in *A. patricia* (Metzler 2000: fig. 2a, b); the valval posterior margin is simple rather than edged with dense setae as in *A. patricia*, and the female sternum 7 (Fig. 1d) is not heavily sclerotized as in *A. patricia* (Metzler 2000: fig. 2c).

**Discussion.** Razowski's (1997) concept of *A. promptana* apparently is based on a misidentified specimen. He did not report examining the specimen designated here as lectotype, which is undoubtedly the Pennsylvania male referred to by Robinson (1869), and thus a syntype. Although Klots (1942) never designated a lectotype, he mentions selecting Robinson's "best specimens" for the purpose. We designate a lectotype to prevent confusion in the future about the identity of this taxon. Razowski's *A. promptana* is described later on here as *A. razowskii*, new species.

**Biology.** Larval foodplants unknown. April–July adult captures suggest a univoltine or bivoltine life cycle.

**Specimens examined** ( $n = 21$ , including lectotype ♂). Counties and months of capture by State and Province: Canada. NOVA SCOTIA: Cumberland, July; Queens, June (CNC, NSRM, UMSP). USA. ILLINOIS: Putnam, May (INHS). MAINE: Washington, July (MAR). MISSISSIPPI: Oktibbeha, April; Tishomingo, May; Warren, April (UMSP, BMMS). MISSOURI: Boone, May (UMRM). NEW JERSEY: Arlington, August (ANSP). OHIO: Montgomery, May (UMSP). PENNSYLVANIA: Allegheny, June (CMNH). WISCONSIN: Burnett, June (MS).

*Aethes angulatana* (Robinson)  
(Fig. 2a–d)

*Conchylis angulatana* Robinson (1869:286, pl. 8, fig. 81) (Lectotype ♀ designated by Klots [1942], type #7442, "Penn.," ND, FW 5.0 mm long, gen. prep. MGP932 [Fig. 2d], in ANSP). Fernald (1882:25), Klots (1942:416), Handfield et al. (1997:44).

*Phalonia angulatana*; Dyar et al. (1903:487), Forbes (1923:508), McDunnough (1939:60), Brower (1983:50).

*Aethes angulatana* (not Robinson 1869); Razowski (1986:394, 1995:139, 1997:123).

*Aethes angulatana*; Grehan et al. (1995:25), Covell (1999:62).

*Phtheochroa angulatana*; Poole and Gentili (1996:876), Nielsen (1998:10).

**Male and female exterior.** Head cream colored, often suffused with darker scales; labial palpus 3× longer than horizontal eye diameter. Notum and tegulum cream and mixed buff, brown, or black; hind leg cream, tibial spurs not contrasting. **FW** (Fig. 2a) 4.8–7.6 mm long ( $n = 53$ ). Ground color cream, often suffused with darker scales; markings a mixture of buff, brown, and black scales, fasciae outlined intermittently with darker scales; basal one-fourth of costa dark, costa and anal margin outlined with short striae; basal fascia extending to costa, protruding slightly into discal cell at midpoint; IM fascia extending into discal cell, often coalescing with discal spot, scattered scales angling from discal spot toward termen and tornus; anal crescent and OM fascia present; ST line extending from tornus to apex; fringe of ground color, often bicolored, with darker basal band the color of FW markings. **HW** dark drab, fringe paler with darker basal band.

**Male genitalia** (Fig. 2b, c) ( $n = 25$ ). Valva broad, costa subsinuate, posterior margin broad, curved, a horseshoe-shaped row of dentiform spines on harpe; sacculus pointed. Median process of transtilla thumb-shaped, apex rounded, with a small terminal process. Aedeagus moderately thick, vesica bearing one long cornutus and a small irregularly shaped bundle of smaller cornuti. Anellus lobes absent.

**Female genitalia** (Fig. 2d) ( $n = 23$ ). Lamella post-vaginalis a small medial round process; bases of apophyses broad, posterior apophyses as long as anterior; antrum robust, long, funnel shaped, tapering anteriorly; ductus bursae sclerotized, coalesced with corpus bursae, corpus bursae slanted to right when viewed as in Fig. 2d. Cervix bursae to the left and dorsad of antrum when similarly viewed.

**Biology.** Larval foodplants unknown. Adults collected mid-June to mid-September. Life cycle probably univoltine.

**Diagnosis.** *A. angulatana* is highly variable in size and markings, with some phenotypes resembling other species; it can be diagnosed best by genitalia. Its large lamella postvaginalis, and lack of a distal aedeagal sclerite differentiate it from *A. promptana* (Figs. 2d, 1d, 2c, 1c); its narrower phallobase apex, and lack of



ventral cervix bursae differentiate it from *A. sexdentata* (Figs. 2d, 5d, 2c, 5c); its smaller lamella postvaginalis, and absence of a blade-shaped aedeagal carina differentiate it from *A. razowskii* (Figs. 2d, 6d, 2c, 6c); its slightly narrower IM fascia, and lack of a distal aedeagal sclerite also differentiate it from *A. razowskii* (Figs. 2c, 7c, 2a, 7a); and its broader harpe and less pronounced cervix bursae differentiate it from *A. matheri* (Figs. 2d, 8d, 2b, 8b). Melanics also occur.

**Discussion.** This species was misidentified by Razowski (1986, 1995, 1997) who based his identification on misidentified specimens. He did not report examining the lectotype. Razowski's *A. angulatana* is described later here as *A. sexdentata*, new species.

**Specimens examined** (n = 53, including type). Counties and months of capture by State or Province: Canada. QUEBEC: Gatineau, July (UMSP). USA. ILLINOIS: Putnam, September (USNM). INDIANA: St. Joseph, July–September (UMSP). MAINE: Franklin, June; Washington, August (MAR). MICHIGAN: Allegan, August; Cass, July, September; Cheboygan, July; Clinton, July, September; Kalamazoo, September; Otsego, August; St. Clair, September; St. Joseph, September (BGS, GJB, JHW, MSUC, UMSP, WPW). MINNESOTA: Wilkin, July (UMSP). NEW JERSEY: Burlington, June, September, October (ANSP). PENNSYLVANIA: Allegheny, August, September; Beaver, August, September (CMNH, USNM). VERMONT: Bennington, August; Chittenden, August; Grand Isle, September (FMPS, MS). WISCONSIN: Burnett, August (MS).

*Aethes argentilimitana* (Robinson)  
(Fig. 3a–d)

*Conchylis argentilimitana* Robinson (1869:287, pl. 8, fig. 82) (Lectotype ♂ designated by Klots [1942], type #7441, "Penn.," ND, gen. prep. MGP931 [Fig. 3c], FWs missing, in ANSP), Fernald (1882:25), Klots (1942:417), Handfield et al. (1997:44), Covell (1999:62).

*Conchylis labeculana* Robinson (1869:287, pl. 8, fig. 83) (Lectotype ♂ designated by Klots [1942], type #7443, "Penn.," ND, gen. prep. MGP934 [Fig. 3b], FW 5.5 mm long [Fig. 3a], in ANSP), Fernald (1882:25), Klots (1942:417), **new synonym**.

*Phalonia argentilimitana*; Dyar et al. (1903:487), McDunnough (1939:60), Brower (1983:50).

*Phalonia labeculana*; Dyar et al. (1903:487), McDunnough (1939:60).

*Aethes argentilimitana*; Grehan et al. (1995:25), Razowski (1997:123, figs. 51–53, 149).

*Phtheochroa argentilimitana*; Poole and Gentili (1996:876).

*Phtheochroa labeculana*; Poole and Gentili (1996:876). *Aethes labeculana* (not Robinson 1869); Razowski (1997:122).

**Male and Female exterior.** Head, notum, and tegulum white; labial palpus 2× longer than horizontal eye diameter. Thoracic tuft inconspicuous, middle and hind legs predominantly buff, tibial spurs not contrasting. **FW** (Fig. 3a) 3.9–6.4 mm long (n = 81). Ground color white; markings buff to raw umber; buff and umber striae on costa and anal margin; basal fascia extending to costa; often suffused basally with buff scales; IM fascia extending into discal cell, scattered scales reaching anal crescent; discal spot minute; OM fascia short, narrow, sometimes coalesced with ST line; ST line irregular, consisting of scattered scales reaching apex; fringe of ground color. **HW** drab; fringe pale, basal line present.

**Male genitalia** (Fig. 3b, c) (n = 16). Costa of valva straight, posterior margin narrowly rounded, apex oblique, harpe spined; sacculus lobed. Aedeagus thick, vesica bearing one stout cornutus and a scobinate patch, lacking small cornuti. Anellus lobes absent.

**Female genitalia** (Fig. 3d) (n = 11). Anterior and posterior apophyses subequal in length. Antrum funnel-shaped, apical half broad, shorter than in *A. angulatana*, often twisted forward almost entire length of ductus bursae; ductus bursae sclerotized, coalesced with the elongate corpus bursae. Cervix bursae located at posterior end of corpus bursae, subequal in size to it.

**Diagnosis.** *A. argentilimitana* is readily recognized by the golden buff FW markings. As noted by Razowski (1997), FW marginal striae are absent in some specimens, which makes their FW ground color solid white.

**Discussion.** Although the type of *A. argentilimitana* lacks forewings, its genitalia are intact, and genitalia of the type of *A. labeculana* do not differ from them. Razowski (1997) misidentified *A. labeculana*, basing his identification on a misidentified specimen. He did not report examining the type.

**Biology.** Larval foodplants unknown. May–October adult capture dates suggest the life cycle is multivoltine. Sabourin has captured adults in dry, open areas of meadows and fields.

**Specimens examined** (n = 81, including types of *A. argentilimitana* and *A. labeculana*). Counties and months of capture by State or Province: Canada. ONTARIO: Muskoka, July (ANSP). USA. ILLINOIS: Putnam, May, June; Union, July (INHS). INDIANA: Elkhart, May; LaGrange, August; Perry, June; St. Joseph, August (JV, UMSP). KENTUCKY: Barren, September; Meade, May; Rockcastle, May (ANSP). MAINE: Kennebec, July (MAR). MASSACHUSETTS: Dukes, July, August (ANSP). MICHIGAN:



Allegan, May; Barry, August; Cass, June; Clinton, June; Washtenaw, July (JHW, UMSP, WPW). MINNESOTA: Anoka, May; Beltrami, June, July; Clearwater, June–August; Marshall, August (UMSP). MISSISSIPPI: Lee, May; Oktibbeha, April, May; Tishomingo, June, July (BMMS, UMSP). NEW JERSEY: Burlington, June–August (ANSP). OHIO: Adams, July; Clermont, May; Hamilton, May–July, September, October (ANSP). PENNSYLVANIA: Allegheny, June, August; Bucks, July (AMNH, CMNH). VERMONT: Chittenden, May, July; Grand Isle, August (MS, FMPS). WISCONSIN: Burnett, May, June, August (UMSP).

*Aethes interruptofasciata* (Robinson),

**revised status**

(Fig. 4a–d)

*Conchylis interruptofasciata* Robinson (1869:287, pl. 8, fig. 85) (Lectotype ♂ designated here, type #7444, “Penn.,” ND, gen. prep. MGP933, FW 5.0 mm long, in ANSP), Fernald (1882:25).

*Phalonia interruptofasciata*; Dyar et al. (1903:487) Forbes (1923:506).

*Phalonia aureana* Busck (1907:25) (Holotype ♀: Pennsylvania, Oak Station, F. Marloff, gen. prep. USNM #24375, in USNM), Forbes (1923:507), McDunnough (1939:60), Procter (1946:308), Covell (1999:62), Brown and Lewis (2000:1021).

*Phalonia sublepidana* Kearfott (1907:82) (Lectotype ♂ designated by Klots [1942], N. J., Caldwell [Essex Co.], W. D. Kearfott, 8 July 1900, gen. prep. MGP810, in AMNH), Forbes (1923:507), McDunnough (1939:60), Procter (1946:308), Brower (1983:50), **new synonym**.

*Phalonia interruptofasciata*; McDunnough (1939:60), Brower (1983:50). Misspelling.

*Phtheochroa aureana*; Poole and Gentili (1996:876).

*Phtheochroa interruptofasciata*; Poole and Gentili (1996:876). Misspelling.

*Phtheochroa sublepidana*; Poole and Gentili (1996:876).

*Aethes labeculana* (not Robinson 1869); Razowski (1997:122, figs. 49, 50, 147, 148).

**Male and female exterior.** Head, tegulum, and thoracic tuft mixed cream and buff, remainder of notum predominantly fuscous; labial palpus 2.5× longer than horizontal eye diameter. Fore- and midlegs fuscous anteriorly, buff posteriorly, mixed fuscous and buff at articulations, hindleg predominantly buff, some fuscous scales posteriorly. **FW** (Fig. 4a) 4.7–7.0 mm (n = 32). Ground color cream, suffused with cinnamon and fuscous scales; markings varying from cinnamon to burnt umber; basal fascia cinnamon; fuscous striae on costa and anal margin; IM fascia cinnamon, short, extending barely into discal cell; anal crescent narrow,

umber, darker than IM fascia, or absent; fuscous scales along veins from discal cell to termen; terminal half of FW suffused with fuscous scales in *sublepidana* phenotype; discal spot not prominent, some cinnamon scaling between IM and OM fasciae; OM fascia extending to tornus, often paler below costa; ST line absent; fringe cream; apex obtuse. **HW** dark drab; fringe a mixture of drab and paler scales.

**Male genitalia** (Fig. 4b, c) (n = 10). Costa of valva subsinuate, posterior margin narrowly rounded, oblique, harpe unspined; sacculus lobed. Sickelike apical structures of socii long. Aedeagus long, thin, curved, vesica with one long cornutus. Anellus lobes absent. Juxta small, rotund, a V-shaped incision at its junction with aedeagus.

**Female genitalia** (Fig. 4d) (n = 5). Anterior and posterior apophyses subequal in length to papillae anales. Sterigma small, crescent shaped; lamella postvaginalis a medial spot; antrum short, cylindrical, 1/6 length of ductus bursae; ductus bursae long, posterior 1/2 sclerotized. Cervix bursae a small fingerlike process on basal left margin of ductus bursae when viewed as in Fig. 4d.

**Diagnosis.** Pale specimens of *A. interruptofasciata* can be differentiated from *A. argentilimitana* by their broader basal fascia, and the OM fascia extending to the tornus (Figs. 4a, 3a). The two taxa also differ markedly in genitalia; males of *A. argentilimitana* possess a spined harpe and those of *A. interruptofasciata* lack it (Figs. 4b, 3b). Material labeled as *A. sublepidana* suggests an undersized *A. interruptofasciata*; no consistent genitalic differences were found between them.

**Discussion.** *A. interruptofasciata* is resurrected from the synonymy of *A. labeculana*. Razowski (1997) synonymized *A. interruptofasciata* under *A. labeculana* based on a misidentified specimen of *A. labeculana* which actually is *A. argentilimitana*. Variability in size and maculation of *A. interruptofasciata* has led to descriptions of some of its phenotypes as separate species. We designate a lectotype to prevent future confusion about the identity of this taxon.

**Biology.** Larval foodplants unknown. Adults captured May 20–August 4. Life cycle probably multivoltine. Sabourin has captured adults in deciduous forest openings and blueberry thickets.

**Specimens examined** (n = 32, including types of *A. interruptofasciata*, *sublepidana*, and *aureana*). Counties and months of capture by State or Province: Canada. MANITOBA (no county system): Aweme, June (CNC). NOVA SCOTIA: Queens, July (NSPM). USA. ILLINOIS: Putnam, July (USNM). MAINE: Washington, July (MAR), MICHIGAN: Cheboygan,



July (BGS). MISSOURI: Wayne, June (JRH). NEW JERSEY: Essex, July (AMNH). PENNSYLVANIA: Allegheny, June–August (AMNH, CMNH). WEST VIRGINIA: Kanawha, May (UMSP). WISCONSIN: Burnett, June, July; Douglas, July; Oneida, July; Vilas, June (EME, GJB, MS, UMSP).

***A. sexdentata* Sabourin and Miller, new species**  
(Fig. 5a–d)

*Aethes* sp. nr. *angulatana*; Grehan et al. (1995:25).

*Aethes angulatana* (not Robinson, 1869); Razowski (1997:123, figs. 54, 55, in part).

**Male and female exterior.** Head and notum white, dusted with buff; labial palpus 3× longer than horizontal eye diameter. Tegulum mixed raw umber, clay, and buff; midleg fuscous anteriorly, with buff scales at junctions of tarsomeres, buff posteriorly; hindleg predominately buff, some fuscous scales on femur, tibial spurs fuscous anteriorly, the shorter of the pairs usually darker. **FW** (Fig. 5a) 5.7–8.2 mm long ( $n = 83$ ). Ground color white, dusted with buff scales except along costa; costa and anal margin outlined with short striae; markings raw umber, clay, and buff; fasciae black bordered; basal fascia broad, extending to costa; IM fascia extending into discal cell, coalescing with discal spot; scattered scales from discal spot angled toward tornus and beyond apex of anal crescent; OM fascia a broad spot; ST line extending from tornus to apex; fringe buff with less mixture of variously colored scales than in *A. angulatana*; terminal line darker than fringe. **HW** dark drab; fringe cream with darker basal band.

**Male genitalia** (Fig. 5b, c) ( $n = 37$ ). Costa of valva slightly curved, posterior margin broad, rounded, 4–12 spines on harpe, but usually 6; sacculus rounded. Median process of transtilla subtriangular. Aedeagus thick, vesica bearing one large cornutus and a bundle of smaller cornuti. Phallobase broadening at apex. Anellus lobes absent.

**Female genitalia** (Fig. 5d) ( $n = 19$ ). Anterior and posterior apophyses subequal in length, longer than papillae anales. Lamella postvaginalis a small medial plate; terminal half of antrum broadening sinistrad when viewed as in Fig. 5d; cervix bursae circular, produced ventrad to base of antrum; tergum 7 lightly sclerotized.

**Types. Holotype:** VERMONT, Grand Isle Co., Grand Isle, Lovers Lane, ♂, 07/27/1995 (M. S. Griggs), FW 7.0 mm long, gen. prep. MS01046 (Fig. 5b, c) (UMSP). **Paratypes** ( $n = 78$ ): Canada. NOVA SCOTIA: Colchester Co., Debert, ♂, 07/20/1961 (D. C. Ferguson), gen. prep. MS00308 (NSPM). ONTARIO: Grand Bend [Huron Co.], ♀, 07/06/1939 (T. N.

Freeman), gen. prep. MS97249. Pt. Colborne [Welland Co.], ♂, 07/13/1932, gen. prep. Ph23; ♂, 05/07/1933 (J. J. deGryse), gen. prep. MS97308 (CNC). Trenton [Northumberland Co.], ♀, 07/12/1912 (Evans) (CNC). QUEBEC: Montreal [Laval Co.], ♂, 07/01/1985 (B. Landry) (MS). USA. CONNECTICUT: Washington [Litchfield Co.], AL, ♂, 06/21/1960, gen. prep. MS00407, coll. #63404; ♂, 06/22/1960, coll. #63404; ♂, 06/20/1961, gen. prep. MS97292, coll. #63406; ♂, 07/17/1960, gen. prep. MS01063, coll. #63399; ♂, 07/21/1960, gen. prep. MS00407, coll. # 63400; ♂, 06/25/1962 (S. A. Hessel), gen. prep. MS97260, coll. # 63421 (YPM). Windham Co., Putnam, ♂, 07/1–4/1959 (Klots), gen. prep. MS01028 (AMNH). ILLINOIS: Algonquin [McHenry Co.], ♂, 07/07/1909, gen. prep. 00738IG. Clark Co., Rocky Branch Preserve, UVL, ♀, 07/03/1995 (T. Harrison), gen. prep. MS98427 (INHS). INDIANA: Elk[hart] Co., LT, ♂, 06/21/1997, gen. prep. MS98413. St Joseph Co., LT, ♂, 07/31/1996 (J. Vargo), gen. prep. MS97290 (UMSP). MAINE: Steuben [Washington Co.], ♂, 06/11/1999, gen. prep. 01072IG; ♀, 07/17/1999, gen. prep. MS01073; ♂, 06/26/2000 (M. A. Roberts), gen. prep. MS01066 (MAR). MASSACHUSETTS: Lancaster [Worcester Co.], ♂, 07/15/1993 (E. Peters) (MS). MICHIGAN: Cass Co., Westrate farm, LT, ♂, 07/16/1999 (J. Vargo), gen. prep. MS99438 (UMSP); T5S R14W Sec. 31, ♂, 06/11/1987 (W. P. Westrate), gen. prep. MS01051 (WPW). Ingham Co., T4N R2W Sec. 35, 3 ♂, 07/20/1968 (J. P. Donahue), gen. prep. 01105IG. Lenawee Co., T8S R2E Sec. 31, 3 ♂, 07/08/1969. Livingston Co., George Reserve, ♀, 07/19/1934 (W. C. Stinson), gen. prep. MS00502. Midland Co., ♀, 08/09/1958 gen. prep. MS01093; ♂, 08/11/1958 (R. R. Dreisbach), gen. prep. MS00727 (MSUC). Muskegon Co., Muskegon S[tate] P[ark] dunes, ♀, 08/11/1989 (G. Balogh), gen. prep. 97293 (GJB). Oakland Co., ♀, 06/26/1933 (W. C. Stinson), gen. prep. 01094IG (MSUC). MINNESOTA: Itasca Pk., LaSalle Valley [Clearwater Co.], AL, ♀, 07/09/1940 (C. E. Mickel), gen. prep. MS01053. Ramsey Co., North Oaks, ♂, 06/28/1965 gen. prep. JAB122; ♂, 08/02/1965 (W. E. Miller), gen. prep. JAB121. Wilkin Co., ♂, 07/11/1937 (D. G. Denning), gen. prep. 01103IG. MISSISSIPPI: Claiborne Co., Rocky Springs, ♂, 05/10/1970, gen. prep. MS00058, coll. #35670. Hinds Co., Clinton, ♂, 11/13/1958, gen. prep. MS99495, coll. #287; ♂, 05/07/1971 (B. Mather), gen. prep. MS99172, coll. #35561 (UMSP). NEBRASKA: Cherry Co., Valentine N[atl.] W[ildlife] R[efuge], Hackberry Lk., LT, ♂, 06/21/1983; ♂, 06/28/1983; ♂, 06/29/1983, gen. prep. MS01223; ♀, 06/30/1983 (R. W. Hodges) (USNM). NEW JERSEY: New Lisbon [Burlington Co.], ♂, 06/17/1933; ♂, 06/18/1933 (E. P. Darlington), gen. prep. MS00243.



PENNSYLVANIA: Philadelphia [Philadelphia Co.], ♂, 07/05/1914 (ANSP). VERMONT: Chittenden Co., Colchester, 07/04/1993, ♀, 3 ♂, gen. prep. MS01037; ♀, 2 ♂, 07/11/1993, gen. preps. MS01150, MS01148; Colchester, railway by bog, 2 ♂, 08/05/1992, gen. prep. MS95013; Shelburne, ♂, 07/04/1993; S. Burlington, ♀, 07/29/1993, gen. prep. MS01146 (MS); ♀, 07/12/1992, gen. prep. MS97250; ♂, 07/28/1992; ♂ (Fig. 5a), 07/07/1993 (M. Sabourin), gen. prep. MS97207. Grand Isle Co., Grand Isle, Lovers Lane, ♀, 07/27/1995 (M. S. Griggs), gen. prep. MS00056 (UMSP). WASHINGTON: Pullman [Whitman Co.], ♂, 05/1935, reared ex *Solidago* stalks, gen. prep. MS00060 (EME); 3 ♂, 2 ♀, 05/1935 (J. F. G. Clarke), reared ex *Solidago* stalks, gen. preps. USNM23877, 23878, 23880, 23980, wing slides MS23877, USNM23878. Walla Walla [Walla Walla Co.], ♂, ♀, 06/06/1931 (D. R. Brannon), gen. preps. USNM23879, 23981 (USNM). WEST VIRGINIA: ♀, no data, gen. prep. MS00013, pseudotype *argenteilimitana* (Klots 1942), Grote and Robinson type #23031 (AMNH). WISCONSIN: Burnett Co., Grantsburg, AL, ♂, 06/07/2000; ♂, 06/26/2000; ♀, 06/23/2001, gen. prep. MS01482; ♀, 07/01/2000, gen. prep. MS00602; ♀, 07/09/2000, gen. prep. MS00621, wing slide MS00621W; ♂, 08/09/2000; T40N R18W Sec. 23, LT, ♂, 06/30/2001, gen. prep. MS01494; ♂, 07/14/2001 (M. Sabourin), gen. prep. MS00601 (MS, ZMUH). Dane Co., Nevin Marsh, ♂, 06/26/1974 (D. T. Bach) (UWEM).

**Diagnosis.** *A. sexdentata* most resembles *A. fernaldana* (Walsingham 1879), the wings of which were illustrated by Walsingham (1879), and the male genitalia by Razowski (1964). We examined the *A. fernaldana* syntypes enumerated below.

*A. sexdentata* differs in its white FW ground color, and markings predominantly of raw umber and buff with black borders, versus the yellow ground with ochreous markings in *A. fernaldana*. In addition, the OM fascia and ST line in *A. sexdentata* are conspicuous and concolorous with the IM fascia, whereas in *A. fernaldana* the OM fascia and ST line are paler than the IM fascia and hardly differentiated from the ground color.

In male genitalia, *A. sexdentata* differs in its more sinuate ventral margin of the valva, and more rounded ventral margin of the sacculus. Further, although FW length of *A. fernaldana* ranges within that given above for *A. sexdentata*, the single large cornutus of *A. sexdentata* is twice as thick and nearly twice as long as that of *A. fernaldana*, and the small cornuti of *A. sexdentata* are larger and twice as numerous as those of *A. fernaldana*. The genitalia preparation of the one female syntype of *A. fernaldana* was in too poor condition for comparison. The cervix bursae of *A. sexdentata*

is ventrad to the antrum, which otherwise separates females of the new species from all known *Aethes*.

**A. fernaldana specimens examined** (n = 3). FW length 7.0–8.5 mm. Type H. T., Hatchet Creek, Shasta Co., California, 07/14–17/1871, *Cochylis fernaldana* Wlsm., type ♂ figd. & descr. . . ., B. M. ♂ genitalia slide No. 4777. Same data except *Cochylis fernaldana* paratype, B. M. ♂ genitalia slide No. 12950. Same data except B. M. ♀ genitalia slide No. 18564 (BM). So far as we know, no types have been formally designated, so these specimens are considered syntypes here.

**Discussion.** This is Razowski's *A. angulatana*, the identity of which was based on a misidentified specimen. Females were associated by FW color pattern and simultaneous capture. One melanic specimen was found. One of the most widely distributed Nearctic *Aethes*, *A. sexdentata* ranges from Nova Scotia west to Washington State, and south to Mississippi and Nebraska.

**Etymology.** The name *sexdentata* refers to the spines on the harpe.

**Biology.** *Solidago* sp. (Asteraceae) is a larval food-plant (Razowski 1997, and data on pinned specimens). Adults were captured May 7–August 11, suggesting a univoltine life cycle.

#### *Aethes razowskii* Sabourin and Miller, new species (Fig. 6a–d)

*Phalonia promptana* (not Robinson, 1869); Forbes (1923:508, in part), Brower (1983:50, in part).

*Aethes promptana* (not Robinson, 1869); Grehan et al. (1995:25), Razowski (1997:124, figs. 56–60, 150–152).

**Male and female exterior.** Head, notum, and tegulum cream colored; labial palpus 3× longer than horizontal eye diameter. Fore- and midlegs darker anteriorly than posteriorly, hindleg with some brownish scales on femur, the smaller tibial spurs darker than the larger ones. **FW** (Fig. 6a) 4.7–8.6 mm long (n = 34). Ground cream colored; markings buff, orange yellow, dark brown, and fuscous; all fasciae bordered by darker scales; basal fascia narrow, extending to costa; striae on costa and anal margin not conspicuous; IM fascia narrow, extending into cell, coalescing with discal spot; discal spot paler than IM fascia, often barely contrasting with ground color; anal crescent present; OM fascia short; ST line extending to vein R<sub>5</sub>, hardly differentiated from ground, orange yellow with a few umber specks to more contrasting and brown in some females; fringe of ground color. **HW** dark drab; fringe paler with narrow basal band.

**Male genitalia** (Fig. 6b, c) (n = 23). Costa of valva subsinuate, posterior margin broad, dorsally oblique, U-shaped row of spines on harpe, spines on exterior



margin longer than those on interior; sacculus broadly rounded. Aedeagus moderately thick, vesica bearing a blade-shaped beak or carina, an elongate scobinate patch, and one large, thick cornutus. Anellus lobes absent.

**Female genitalia** (Fig. 6d) ( $n = 4$ ). Anterior and posterior apophyses subequal in length to papillae anales. Lamella postvaginalis a subquadrate medial plate; antrum cylindrical; ductus bursae sclerotized entire length. Cervix bursae subquadrate, not notably separated from corpus bursae.

**Types. Holotype:** MICHIGAN, Schoolcraft Co., T42N R16W Secs. 11, 13, ♂, 07/04/1987 (G. Balogh), FW 6.5 mm long, gen. prep. MS01050 (Fig. 6b) (AMNH). **Paratypes** ( $n = 19$ ): Canada. NOVA SCOTIA: Round Hill [Annapolis Co.], ♂, 06/24/1961 (H. Stultz) (NSPM). QUEBEC: Knowlton [Brome Co.], 2 ♂, 06/09/1936 (G. S. Walley), gen. prep. Ph13 (CNC). USA. ALABAMA: Winston Co., ♂, 04/11/1999, gen. prep. MS99196; ♀, gen. prep. MS99197 (MS). CONNECTICUT: Windham Co., Putnam, ♀, 08/13–16/1961 (A. B. Klots), gen. prep. MS00202 (AMNH). IDAHO: Wallace [Shoshone Co.], ♂, 3000 ft., Sweadner collection, 06/22–30, gen. prep. MS00245 (CMNH). INDIANA: St. Joseph Co., LT, ♂, 06/20/1999 (J. Vargo), gen. prep. IG (JV). MAINE: Rangeley [Franklin Co.], ♂, 07/10/1938; ♀, 06/23/1938 (V. H. dos Passos), gen. preps. 00062IG, MS00016 (AMNH). MARYLAND: Baltimore Co., Prettyboy Reservoir, ♂, 08/24/2001, coll. #4, gen. prep. MS02029; Soldiers Delight, ♂, 04/25/1998; ♂, 05/25/1997, gen. prep. MS02205; ♂, 05/15/2000, gen. prep. MS0220; ♂, 06/14/1997; 2 ♂, 07/05/1997; ♂, 08/07/1997; ♂, 09/06/1998; ♀, 09/30/1998, gen. prep. MS02206; ♂, 09/19/1998, gen. prep. MS02182; ♂, 05/15/1998, gen. prep. IG02184 (J. Glaser) (JDG). MICHIGAN: Allegan Co., T2N R14W Sec. 26, ♂ (Fig. 6a), 5/30/1986 (G. Balogh), gen. prep. MS97310 (GJB). Cass Co., T5S R14W Sec. 31, ♂, 07/25/1996 (W. P. Westrate), gen. prep. IG (WPW); LT, 2 ♂, 09/03/1999, gen. prep. IG; ♂, 09/25/1999 (J. Vargo), gen. prep. MS99529 (UMSP). Gladwin Co., ♂, 06/25/1959 (R. R. Dreisbach), gen. prep. 01108IG (MSUC). Livingston Co., George Reserve, AL, ♂, 07/22/1938 (S. Moore), gen. prep. MS01101 (UMMZ). Schoolcraft Co., T42N R16W Secs. 11, 13, ♂, 07/04/1987 (G. Balogh), gen. prep. MS01050 (GJB). St. Joseph Co., Three Rivers, LT, ♂, 05/29/1999 (J. Vargo), gen. prep. MS99439, wing slide MS99439W (UMSP). Washtenaw Co., T3S R3E Sec. 29, ♂, 05/30/1992 (B. G. Scholtens), gen. prep. 00027IG (BGS); T2S R3E Sec. 6, ♀, 07/19/1993 (J. H. Wilterding), gen. prep. MS00499 (JHW). NEW HAMPSHIRE: Coos Co., Whitefield, BLT, ♀, 07/11/1992 (W. Kiel), gen. prep. MS01496 (MS). VERMONT: Ferdi-

nand [Essex Co.], ♂, 06/23/1993 (M. Sabourin), gen. prep. 00247IG (UMSP).

**Diagnosis.** *A. razowskii* most resembles *A. promptana*. FW markings in *A. razowskii* are usually more contrasting with ground color and outlined by darker scales (Figs. 6a, 1a). In male genitalia, *A. razowskii* differs from *A. promptana* in its oblique posterior margin of the valva and well rounded ventral margin of the sacculus, compared with the curved posterior margin of the valva and straight margin of the sacculus in *A. promptana* (Figs. 6b, 1b). Also, the aedeagus of *A. razowskii* has a blade-shaped carina, which is absent in *A. promptana* (Figs. 6c, 1c). In female genitalia, the antrum of *A. razowskii* is more cylindrical and the lamella postvaginalis smaller than in *A. promptana* (Figs. 6d, 1d). *A. razowskii* is superficially similar to some individuals of *A. angulatana*, but in *A. razowskii* the IM fascia is narrower, the ST line paler, and the genitalia are different (Figs. 6a–d, 2a–d).

**Discussion.** Razowski (1997) and earlier authors misidentified this species as *A. promptana*. Females were associated by FW color pattern and simultaneous capture.

**Etymology.** This species is named in honor of Dr. Josef Razowski in recognition of his continuing efforts to illuminate the world tortricid fauna.

**Biology.** Larval foodplants are unknown. May–September adult capture dates suggest a multivoltine life cycle.

***Aethes westratei* Sabourin and Miller,  
new species  
(Fig. 7a–d)**

**Male and female exterior.** Head and notum usually unicolorous cream to tawny, antennal scape darker than head; labial palpus white apically, 3× longer than horizontal eye diameter. Thoracic tuft conspicuous, tegulum brown, darker than notum; fore- and midlegs fuscous anteriorly with buff scales at articulations, hindleg predominately buff except for fuscous scales anteriorly on shorter tibial spurs. **FW** (Fig. 7a) 6.9 mm long ( $n = 9$ ). Ground color cream, suffused with brownish scales, basal area suffused with tawny scales, posterior 3/4 often suffused with grayish scales; markings brown; fasciae with darker brown or black borders; basal fascia extending slightly into discal cell at midpoint, also to costa; costa and anal margins with short striae; IM fascia broad, coalescing with discal spot; anal crescent and OM fascia present; ST line irregular, but extending to apex; fringe cream with some brown scales; terminal line darker than fringe. **HW** olive-brown; fringe paler, with basal band.

**Male genitalia** (Fig. 7b, c) ( $n = 4$ ). Costa of valva



straight, posterior margin rounded, sinuate, harpe spined; sacculus subtriangular, ventrally rounded. Median process of transtilla subtriangular. Aedeagus thick, vesica bearing one large cornutus, a bundle of small cornuti, and a distal crescent-shaped sclerite. Anellus lobes absent.

**Female genitalia** (Fig. 7d) ( $n = 1$ ). Anterior and posterior apophyses equal in length; antrum funnel shaped, almost as long as ductus bursae, right margin straight, left margin bowed at 1/3 its length when viewed as in Fig. 7d. Cervix bursae sinistrocudad of corpus bursae when similarly viewed, and small. Corpus bursae elongate, slightly slanted.

**Types. Holotype:** MICHIGAN, Cass Co., T5S R14W Sec. 31, UV, ♂, 09/02/1995 (M. C. Nielsen), FW 6.5 mm long, gen. prep. MS97289 (AMNH).

**Paratypes** ( $n = 8$ ): MICHIGAN: Barry Co., Shaw Lk., T3N R10W Sec 3, 2 ♂, 09/09/1986 (G. Balogh) (GJB). Cass Co., LT, ♂, 09/06/1997, gen. prep. MS97325; ♀ (Fig. 7a), same data (J. Vargo), gen. prep. MS98146 (UMSP); T5S R14W Sec. 31, UV, ♂, 09/02/1995 (M. C. Nielsen), gen. prep. MS01039 (MSUC); same locality, ♂, 09/02/1988; ♂, 09/09/1988 (W. P. Westrate), gen. prep. MS01048, wing slide MS01048W (WPW); Dr. Lawless C[ounty] P[ark], T6S R13W Sec. 32, UV, ♂, 09/01/1995 (M. C. Nielsen) (MSUC).

**Diagnosis.** *A. westratei* most resembles *A. angulatana* superficially and genitally. The broad IM fascia is a distinguishing feature, being broader in *A. westratei* than in *A. angulatana* (Figs. 7a, 2a). In male genitalia, the harpe of *A. westratei* is more heavily spined than in *A. angulatana*, the posterior margin of the valva less sinuous, and the sacculus less acute (Figs. 7b, 2b). In female genitalia, the anterior and posterior apophyses are shorter and the corpus bursae less slanted than in *A. angulatana* (Figs. 7d, 2d).

**Discussion.** Females were associated by FW color pattern and simultaneous capture.

**Etymology.** This species is named in honor of William P. Westrate in recognition of his activities to illuminate southern Michigan's flora and fauna.

**Biology.** Larval foodplants unknown. September adult capture dates suggest a univoltine life cycle.

***Aethes matheri* Sabourin & Miller,  
new species  
(Fig. 8a–d)**

*Phalonia angulatana* (not Robinson, 1869); Kimball (1965:270).

**Male and female exterior.** Head, notum, and tegulum usually cream or buff; labial palpus 2.5× longer than horizontal eye diameter. Hindleg without markings. **FW** (Fig. 8a) 4.4–6.6 mm long ( $n = 57$ ).

Ground color variable, usually cream or buff; markings buff and brown or cinnamon, fasciae outlined with fuscous scales; basal 1/4 of costal margin fuscous; short striae on costal and anal margins; basal fascia variably projecting slightly into discal cell at midpoint and extending to costa or costal half, diffuse, or absent; IM fascia extending into cell, bordered by or joining discal spot; anal crescent and OM fascia present; ST line present, not reaching apex, variable in color, often not differentiated; terminal line darker than fringe; fringe a mix of cream, cinnamon, buff, and brown scales, paler at tornus. **HW** pale drab; fringe paler with thin basal band.

**Male genitalia** (Fig. 8b, c) ( $n = 34$ ). Costa of valva straight, posterior margin narrowly rounded, harpe spined; sacculus pointed. Median process of transtilla triangular, rounded apically. Aedeagus laterally triangular at apex, vesica bearing one stout cornutus and a bundle of smaller cornuti. Anellus lobes absent.

**Female genitalia** (Fig. 8d) ( $n = 17$ ). Posterior apophyses longer than anterior; left margin of antrum irregular when viewed as in Fig. 8d; ductus bursae coalescing with corpus bursae; cervix bursae sinistrocudad of corpus bursae when viewed as in Fig. 8d, subquadrate; corpus bursae elongate; tergum 7 lightly sclerotized.

**Types. Holotype** (Fig. 8a): MISSISSIPPI, Long Beach [Harrison Co.], ♂, 03/30/1997 (R. Kergosien), gen. prep. MS99483, FW 5.0 mm long, coll. #180525 (AMNH). **Paratypes** ( $n = 56$ ): FLORIDA: Dade Co., Florida City, ♀, 04/02/1947; ♂, gen. prep. MS01137; ♂, 05/02/1947, gen. prep. MS01134; ♀, 05/04/1947, gen. prep. MS01109; ♂, 05/06/1947 (O. Buchholz), gen. prep. MS01101; R. Palm Pk., AL, 3 ♀, 03/14/1938 (E. P. Darlington), gen. preps. 01136, MS01089 (ANSP). ILLINOIS: Coles Co., T12N R6E Sec. 11, UVL, ♀, 06/05/1997 (T. Harrison), gen. prep. MS98437. Putnam Co., ♂, 07/06/1967 (M. O. Glenn), gen. prep. MS97297 (INHS). INDIANA: Elk[hart] Co., LT, 3 ♂, 05/29/1999, gen. prep. MS01080. St. Joseph Co., LT, ♂, 06/20/1999, gen. prep. MS00611; ♂, 06/23/1999, gen. prep. MS99508; ♂, 08/07/1999 (J. Vargo), gen. prep. 00254IG (UMSP). MAINE: Bangor [Penobscot Co.], overgrown field across from Roadway Inn, *Cornus*, *Alder*, *Spiraea*, common, 08:50–09:50 h, 2 ♂, 06/20/1997 (M. Sabourin), gen. prep. 00707IG (MS); ♂, same data, gen. prep. MS97350 (UMSP). Steuben [Washington Co.], ♂, 06/10/1991, gen. prep. G1797; ♂, 07/07/1993 (M. A. Roberts), gen. prep. G1791 (MAR). MARYLAND: Baltimore Co., Towson, ♂, 06/05/1999 (J. Glaser), gen. prep. 02204IG (JDG). MICHIGAN: Barry Co., Shaw Lk., T3N R10W Sec. 3, ♂, 06/30/1989 (G. Balogh), gen. prep. MS99189 (GJB). Shiawassee



Co., Moon Lk., T5N R1E Sec. 21, ♂, 06/25/1969 (J. P. Donahue), gen. prep. MS01100 (MSUC). St. Joseph Co., Three Rivers, LT, 2 ♂, 05/9/1999, gen. preps. MS99226, 99447; ♀, same date (J. Vargo), gen. prep. MS99227 (UMSP). MISSISSIPPI: Hancock Co., Bay St. Louis, ♀, 03/24/1972 (R. Kergosien), gen. prep. MS99170, coll. #106143. Harrison Co., Handsboro, ♀, 04/14/1966 (R. T. Taylor), gen. prep. IG, coll. #21264; Long Beach, ♀, 04/14/1978, gen. prep. MS01132, coll. #126347; ♂, 03/31/1997, gen. prep. IG, coll. #180569; ♂, 04/09/1997, gen. prep. IG, coll. #180549; ♂, ♀, 06/29/1997 (R. Kergosien), coll. #180550, #180570, gen. prep. IG (UMSP). Hinds Co., Clinton, ♂, 09/02/1962 (B. Mather), coll. #11986 (BMMS); ♂, 03/06/1995 (M. & E. Roshore), coll. #180543; Jackson, ♂, 04/07/1963, gen. prep. MS01082, coll. #13179; ♀, 10/07/1961, gen. prep. IG, coll. #8303; ♂, 04/30/1966, gen. prep. MS01131, coll. #21278; ♀, 10/08/1966 (B. Mather), gen. prep. MS99436, coll. #22976. Jackson Co., Shepard S[tate] P[ark], ♂, 08/28/1965, gen. prep. MS99040, coll. #20421; ♂, 08/15–22/1995, gen. prep. 99524, coll. #175647; ♀, 09/6–11/1995, gen. prep. MS99275, wing slide MS99275W, coll. #164312. Rankin Co., Pearl, ♀, 03/31/1963 (B. Mather), gen. prep. IG, coll. #13177 (UMSP). Tishomingo Co., J. P. Coleman S[tate] P[ark], ♂, 06/10–24/1995, gen. prep. MS99282, coll. #164313 (BMMS); ♂, 07/10–21/1995 (R. Kergosien), gen. prep. 99485, coll. #180567 (UMSP). MISSOURI: Columbia [Boone Co.], ♀, 07/22/1985 (W. S. Craig), gen. prep. MS99253 (UMRM). NORTH CAROLINA: Raleigh [Wake Co.], ♂, 08/10/1938 (M. W. Wing), gen. prep. MS01135 (ANSP). PENNSYLVANIA: Allegheny Co., 4 km N of Tarentum, ♂, 06/22/1989 (W. Zanol), gen. prep. MS01107; Pittsburgh, ♀, 06/21/1905 (H. Engel), gen. prep. 01095; ♀, 06/27/1907 (H. Kahl), gen. prep. MS00501 (CMNH). TENNESSEE: Oak Ridge [Roane Co.], ♂, 04/27/1966 (B. Mather), gen. prep. MS99441, coll. #21217 (UMSP). TEXAS: Beaumont [Jefferson Co.], ♀, 08/02/1991 (C. Bordelon), gen. prep. MS01149 (MS).

**Diagnosis.** *A. matheri* most resembles *A. angulatana*. Superficially, *A. matheri* differs in its smaller size, more obscure basal fascia, narrower IM fascia, and ST line not reaching apex (Figs. 8a, 2a). In male genitalia of *A. matheri*, the valva is narrower distally, the base of the transtilla median process broader, and the apex of the aedeagus more acute (Figs. 8b, c, 2b, c). In *A. matheri* female genitalia, the left side of the antrum is more irregular, cervix bursae more conspicuous, and corpus bursae straighter than in *A. angulatana* when viewed as in Figs. 8d and 2d. *A. matheri* differs from *A. sexdentata* in male genitalia, the former, for ex-

ample, having an acute sacculus, and the latter an obtuse one (Figs. 8b, 5b).

**Discussion.** The triangular process of the aedeagus can be seen by brushing away scales at the tip of the abdomen. Northern specimens of *A. matheri* are larger and have a less acute termination of the aedeagus. Females were associated by FW color pattern and simultaneous capture.

**Etymology.** This species is named for Bryant Mather in recognition of his long dedication to collecting Lepidoptera.

**Biology.** Larval foodplants are unknown. March–November adult capture dates in the southern part of range suggest a bivoltine life cycle there; May and June capture dates in the northern part of range suggest univoltinism there. In the north, this species flies earlier than *A. angulatana*.

***Aethes terriae* Sabourin & Miller,  
new species  
(Fig. 9a–c)**

**Male exterior.** Head, tegulum, and notum white, labial palpus 2× longer than horizontal eye diameter, second segment white apically. Fore- and midlegs black anteriorly with buff scales at junctions of tarsi, the longer tibial spur of middle leg buff; hindleg predominately buff, a few dark scales on the shorter tibial spur. **FW** (Fig. 9a) 5.3 mm long (n = 3). Ground color white; markings black or buff with scattered buff scales; minute striae on costal and anal margins; costa black to basal fascia; basal fascia extending to costa, or obscure just below costa; IM fascia short, not extending into discal cell, a few buff scales on apical margin; anal crescent narrow, buff with black borders; discal spot obscure; OM fascia present; ST line buff with black border, extending only to vein M<sub>2</sub>; fringe white with scattered buff and brown scales. **HW** pale drab; fringe paler; basal band present.

**Male genitalia** (Fig. 9b, c) (n = 3). Costa of valva sinuate, posterior margin rounded, bearing a hooklike process ventrally; sacculus rounded. Median process of transtilla short, triangular. Sicklike apical structures of socii short. Aedeagus apically falcate, vesica bearing one long cornutus. Anellus lobes absent. Juxta a small subrectangular plate.

**Types.** **Holotype** (Fig. 9a): MICHIGAN, Kalamazoo Co., wet deciduous forest east side Sugarloaf Lake, ♂, 07/03/1993 (G. J. Balogh), FW 5.0 mm long, gen. prep. MS 99200 (AMNH). **Paratypes** (n = 2): MICHIGAN: Cass Co., Westrate farm, LT, ♂, 07/16/1999 (J. Vargo), gen. prep. MS01088 (Fig. 9b, c), wing slide MS01088W (UMSP); ♂, same data as holotype, gen. prep. MS01069 (GJB).



**Diagnosis.** Superficially, *A. terriae* resembles a small *A. sexdentata*. It differs from *A. sexdentata* superficially in its IM fascia not extending beyond discal cell, narrower anal crescent, and ST line not reaching apex (Figs. 9a, 5a). In male genitalia, *A. terriae* differs from *A. sexdentata* in that the posterior margin of its valva is evenly rounded, with a hooklike spine on the ventral margin, transtilla with a short median process, an apically falcate aedeagus, and a single cornutus (Fig. 9b, c); in contrast, the valva of *A. sexdentata* has a more narrowly rounded posterior margin with a few spines near the outer margin of the harpe, a larger median process of transtilla, a small bundle of cornuti in addition to one large cornutus, and the aedeagus lacks a falcate apex (Fig. 5b, c).

**Discussion.** The female of *A. terriae* is unknown.

**Etymology.** This species is named in honor of Terri Balogh for her hospitality to lepidopterists.

**Biology.** Larval foodplants are unknown. July 3–16 adult capture dates suggest a univoltine life cycle.

***Aethes baloghi* Sabourin & Metzler,  
new species  
(Fig. 10a–d)**

**Male and female exterior.** Head and notum mixed cream and buff; labial palpus 2× longer than horizontal eye diameter, apex cream colored. **FW** (Fig. 10a) 4.0–6.8 mm long (n = 155). Ground cream suffused with buff; markings orange brown; fasciae dark bordered except for basal fascia; basal fascia oblique, costal half indiscernible; basal 1/4 of costa same color as markings; costal and anal margins with minute striae; IM fascia extending through cell, joined with discal spot, angled toward tornus; OM fascia reduced to a few scales near costa; ST line not conspicuous, consisting of a few scattered dark scales not reaching apex; fringe of ground color, but orange-brown on tornus adjacent to anal crescent. **HW** dark drab; fringe cream with a darker basal line.

**Male genitalia** (Fig. 10b, c) (n = 15). Costa of valva fairly straight, posterior margin digitiform; sacculus rounded. Median process of transtilla long, broad, tapering terminally to a twisted apex. Aedeagus apically falcate, vesica bearing a scobinate patch, but no cornuti. Anellus lobes lateral and asymmetrical, inner margin spinose terminally. Juxta broad, crescent shaped.

**Female genitalia** (Fig. 10d) (n = 14). Anterior and posterior apophyses subequal in length to papillae anales. Sterigma, antrum, and ductus bursae reduced; sterigma a C-shaped sclerotized ridge; corpus bursae large, bulbous. Signum a sclerotized area on caudal right half of corpus bursae when viewed as in Fig. 10d. Surface of sternum 7 with heavily sculpted, irregular ridges. Cervix bursae indiscernible.

**Types. Holotype** (Fig. 10a): NEW YORK, Yonkers [Westchester Co.], ♀, 06/19/1936 (A. B. Klots), FW 6.5 mm long, gen. prep. MS00061 (AMNH). **Paratypes** (n = 154): ILLINOIS: Waukegan [Lake Co.], ♀, 08/17/1941 (A. K. Wyatt), 309 (FMNH). Putnam Co., ♂, 09/20/1959; ♂, 09/17/1964 (M. O. Glenn) (USNM). INDIANA: Lagrange Co., LT, ♂, 07/26/1996. St. Joseph Co., LT, ♀, 08/07/1999, gen. prep. 00424IG, wing slide MS00424W (UMSP); 3 ♂, 07/28/1999; 3 ♂, 08/26/1999; ♂, 08/26/1999, gen. prep. EHM253; 3 ♂, 08/28/1999 (J. Vargo) (JV). Hessville [Lake Co.], ♀, 06/30/1905 (A. Kwiat), gen. prep. IG (USNM). MASSACHUSETTS: Martha's Vineyard [Dukes Co.], ♂, 08/11/1944 (F. M. Jones), gen. prep. IG (USNM). MICHIGAN: Allegan Co., T2N R14W Sec. 7, 2 ♂, 05/22–24/1970 (J. P. Donahue), gen. prep. MS97345IG (MSUC); T2N R15W Sec. 25, ♂, A[llegan] S[tate] G[ame] A[rea], 07/21/1984; T3N R15W Sec. 36, ♀, 05/03/1991, gen. prep. IG; T2N R14W Sec. 26, ♀, 09/09/1989; 4 ♂, 2 ♀, 07/25/1987; ♂, ♀, 09/19/1989, gen. prep. EHM251; sand prairie, savanna, 56 ♂, 15 ♀, 08/22/1986, gen. preps. IG, MS97350, EHM250, 252; 2 ♂, 09/19/1987, gen. prep. MS97347; T3N R14W Sec. 31, ♂, 05/11/1991; sand prairie/savanna, ♀, 2 ♂, 07/25/1992, gen. prep. EHM254 (G. Balogh) (GJB); A[llegan] C[ounty] G[ame] P[reserve], LT, 2 ♂, 07/17/1999, gen. prep. MS99322; A[llegan] S[tate] G[ame] A[rea], 8 ♂, 05/26/2000 (J. Vargo), gen. preps. 00423IG, MS01083 (Fig. 10b) (UMSP). Cheboygan Co., Grass Bay, T38N R5W Sec. 25, ♂, 08/04/1995, gen. prep. IG (BGS); T37N R3W Sec. 33, ♀, 06/25/1990 (B. G. Scholtens), gen. prep. MS99154 (UMSP). Emmet Co., Wilderness S[tate] P[ark], base of Waugoshance Point, ♂, 05/27/1990, gen. prep. IG (G. Balogh) (GJB). Lk. Lansing [Ingham Co.], 3 ♀, 09/20/1936, gen. prep. MS01097; 3 ♂, same data (W. C. Stinson), gen. preps. IG (MSUC). Mackinaw Co., T41N R5W Sec. 23, ♀, 08/15/1998, dunes (G. Balogh) (GJB). Montcalm Co., T12N R10W Sec. 18, ♂, 05/09/1987 (G. Balogh), gen. prep. IG. Muskegon Co., T12N R17W Sec. 26, sand prairie/savanna, 3 ♂, 06/11/1993, gen. prep. IG; Muskegon S[tate] P[ark] dunes, ♂, 07/13/1991; ♂, 08/12/1989; ♂, 07/15/1991 (G. Balogh) (GJB). Newaygo Co., T12N R12W Sec. 1, ♂, 07/14/1967 (J. P. Donahue), gen. prep. MS01098 (Fig. 10c). Wayne Co., ♀, 09/14/1943 (J. H. Newman), gen. prep. IG (MSUC). MISSISSIPPI: Harrison Co., Long Beach, ♀, 03/07/1991, gen. prep. IG, coll. #180535; ♂, 03/20/1998, gen. prep. IG, coll. #180537 (BMMS); ♂, 03/13/1991, gen. prep. IG, coll. #180534; ♀, 04/23/1991, gen. prep. IG, coll. #180553; ♂, 04/30/1997, gen. prep. IG, coll. #180548 (R. Kergosien) (UMSP). MISSOURI: Barry



Co., Roaring River S[tate] P[ark], Ozark plateau flora, BL, ♀, 09/03/1994, gen. prep. MS99178 (RL); ♀, same data, gen. prep. MS99180 (UMSP). Columbia [Boone Co.], ♀, 09/17/1983 (W. S. Craig), gen. prep. MS98164 (UM). NEW JERSEY: Franklinville [Gloucester Co.], ♀, 08/18/1939 (W. Sachse). Lakehurst [Ocean Co.], ♀, 09/04/1937, gen. prep. MS01054; AL, ♂, 08/08/1939. New Lisbon [Burlington Co.], AL, ♂, 09/23/1935; ♀, 07/06/1942, gen. prep. MS00240; Whitesbog, AL, ♀, 07/31/1938 (E. P. Darlington), gen. prep. MS01077 (Fig. 10d)(ANSP). NEW YORK: Yonkers [Westchester Co.], ♂, 06/06/1936; ♀, 09/14/1936 (Klots) (AMNH). NORTH CAROLINA: So[uthern] Pines [Moore Co.], ♀, 04/1–7, gen. prep. IG. VIRGINIA: Glencarlyn [Arlington Co.], ♀, AL, 05/26/1959 (J. Armstrong), gen. prep. IG (USNM).

**Diagnosis.** *A. baloghi* most resembles *A. patricia* Metzler, but differs in having orange-brown FW markings compared to the buff markings of *A. patricia*. In male genitalia of *A. baloghi* the posterior margin of the valva is digitiform, not outlined with dense setae, the sacculus is undemarcated, and anellus lobes are present (Fig. 10b, c); in contrast, *A. patricia* has the posterior margin of the valva concave, outlined with dense setae, tipped with a short tooth, the sacculus as a separate lobe, and anellus lobes are absent (Metzler 2000: fig. 2a, b). In female genitalia, *A. baloghi* has a conspicuous signum and sculptured seventh sternum (Fig. 10d), whereas *A. patricia* lacks a signum, and sternum 7 has two heavily sclerotized areas laterad to the ostium bursae (Metzler 2000: fig. 2c).

**Discussion.** Males were associated by FW color pattern and simultaneous capture.

**Etymology.** This species is named for George J. Balogh in recognition of his dedication to lepidopterology.

**Biology.** Larval foodplants unknown. Associated with prairie habitat in parts of range. March–September adult capture dates suggest a multivoltine life cycle.

*Aethes atomosana* (Busck)  
(Fig. 11a–d)

*Phalonia atomosana* Busck (1907:22) (Holotype ♀ [incorrectly given as ♂ by Brown & Lewis 2000], type #10223, Pa., Pittsburgh [Allegheny Co.], H. Engel, 08/17/1905, forewing 8.0 mm long, gen. prep. USNM23825, in USNM), Forbes (1923:509), McDunnough (1939:59), Procter (1946:308), Brower (1983:49, in part), Handfield (1997:44), Brown and Lewis (2000:1020).

*Aethes atomosana*; Grehan et al. (1995:25), Razowski (1997:127, figs. 82–84, 163–165).

*Phtheochroa atomosana*; Poole and Gentili (1996:876), Nielsen (1998:10).

**Male and female exterior.** Head, notum, and tegulum chamois colored; labial palpus 3.0–3.5× longer than horizontal eye diameter. Thoracic tuft conspicuous. **FW** (Fig. 11a) 6.6–9.8 mm long (n = 34). Ground color chamois; markings reduced, represented by black and buff scales; some specimens completely irrorated with fuscous scales, others less maculate with no markings above vein Sc; fuscous striae along anal margin and distally on costa beyond vein Sc; basal fascia vestigial, serial black spots along vein Sc; IM and OM fasciae absent; discal spot present; anal crescent reduced to a submarginal spot; ST line represented by paired spots reaching apex; fringe of ground color; heavy fuscous scaling on underside excluding margins. **HW** cream to fawn colored.

**Male genitalia** (Fig. 11b, c) (n = 10). Costa of valva slightly curved, posterior margin subsinuate, oblique, serrated, with apical spine; sacculus rounded, forming a subharpal plate. Median process of transtilla large, thumb shaped, apex broadly rounded, with 4 or more short apical processes. Aedeagus bearing a medial process, vesica bearing one long, thin cornutus. Anellus lobes bilateral and appressed. Juxta large, subovate.

**Female genitalia** (Fig. 11d) (n = 4). Lamella postvaginalis a long elliptical plate; anterior apophyses longer than posterior; sternum 7 heavily sclerotized, a pair of raised ridges creating a medial furrow ventrad of antrum; antrum cylindrical, ½ as long as ductus bursae. Cervix bursae indiscernible.

**Diagnosis.** *A. atomosana* most resembles *A. matthewcruzi*, which is described and differentiated in the next section.

**Biology.** Larval foodplants unknown. Early August to mid-September adult captures suggest a univoltine life cycle.

**Specimens examined** (n = 34, including type). Counties and months of capture by State or Province: Canada. NOVA SCOTIA: Kings, August; Lunenburg, August (MS, NSPM, UMSP). ONTARIO: Carleton, August (CNC). USA. ILLINOIS: Algonquin, August (INHS). INDIANA: Lagrange, August (JV). MARYLAND: Garrett, September (JDG). MICHIGAN: Barry, September; Cass, September; Cheboygan, August; Clinton, September; Kalamazoo, August; Livingston, September; Midland, August (BGS, GJB, MSUC, UMSP, WPW). PENNSYLVANIA: Allegheny, August (USNM). VERMONT: Addison, August; Chittenden, August, September; Franklin, August; Grand Isle, September (FMPS, MS, MSG). WISCONSIN: Burnett, August (MS).



***Aethes matthewcruzi* Sabourin & Vargo,  
new species  
(Fig. 12a–d)**

**Male and female exterior.** Head cream with brown suffusion; labial palpus 2.5–3.0× longer than horizontal eye diameter. Notum and tegulum cream with brown suffusion or mixed black, buff, and brown; hindleg anterior spurs and shorter tibial spurs with some darker scales. **FW** (Fig. 12a) 6.9–9.2 mm long ( $n = 12$ ). Ground color cream with brown suffusion especially between veins; markings reduced to small, black, buff, and brown spots; basal  $\frac{1}{4}$  of costa gray, costa and anal margin with fuscous striae; IM and OM fasciae and anal crescent reduced to submarginal black spots; discal spot the most conspicuous marking, a mixture of black and buff scales; gray patch between discal spot and anal crescent extending to tornus; ST line represented by black and buff spots, not extending to apex; fringe cream colored with basal line the color of FW markings; heavy fuscous scaling on entire underside. **HW** drab-gray.

**Male genitalia** (Fig. 12b, c) ( $n = 5$ ). Valva broad, costa slightly curved, posteriorly deeply emarginate, serrated; sacculus long, slightly curved, tapering distally. Median process of transtilla triangular, apical half narrowing to a point. Phallobase narrow and curving to a 45° angle to aedeagus. Aedeagus thick, vesica bearing one long, thin cornutus and an elongate scobinate patch. Anellus lobes (Fig. 12c) long and narrow.

**Female genitalia** (Fig. 12d) ( $n = 4$ ). Sterigma subquadrate; lamella postvaginalis a medial process; apophyses long, anterior longer than posterior; antrum a robust collar,  $\frac{1}{2}$  as long as ductus bursae; ductus bursae sclerotized entire length.

**Types.** **Holotype** (Fig. 12a): MINNESOTA, Roseau Co., Lost River S[tate] F[orest], AL, ♂, 08/22/1999 (Vargo & Sabourin), forewing length 8.0 mm, gen. prep. MS00167 (Fig. 12b, c) (UMSP). **Paratypes** ( $n = 11$ ): MAINE: Steuben [Washington Co.], ♂, 08/02/1990 (M. A. Roberts), gen. prep. G1786 (MAR). MICHIGAN: Allegan Co., Saugatuck S[tate] P[ark], ♀, 08/08/1992, gen. prep. MS97269. Barry Co., fen on Shaw Lk., T3N R14W Sec. 3, ♂, 06/26/1991 (G. Balogh), gen. prep. MS01055 (GJB). Cass Co., T5S R14W Sec. 31, ♀, 08/22/1996 (W. P. Westrate), gen. prep. MS01030 (WPW). Washtenaw Co., T2S R3E Sec. 6, ♂, 07/26/1993 (J. H. Wilterding), gen. prep. MS00298, wing slide MS00298W (JHW). MINNESOTA: Same data as holotype, 4 ♂, gen. prep. MS99543 (MS). NEW HAMPSHIRE: Whitefield [Coos Co.], ♀, 08/07/1985 (W. J. Kiel), gen. prep. MS97209 (UMSP). WISCONSIN: Burnett Co.,

Grantsburg, AL, ♀, 07/28/1999, gen. prep. MS00342 (Fig. 12d), wing slide MS00342W; T40N R18W Sec. 23, LT, ♂, 07/14/2001 (M. Sabourin) (MS).

**Diagnosis.** *A. matthewcruzi* is most similar to *A. atomosana*, from which it differs subtly in FW markings, and more markedly in genitalia. *A. matthewcruzi* has fuscous striae on the basal  $\frac{1}{4}$  of the FW costal margin which are absent in *A. atomosana*, and the OM and IM fasciae, which are reduced to submarginal spots in *A. matthewcruzi*, are lacking completely in *A. atomosana* (Figs. 12a, 11a). In male genitalia of *A. matthewcruzi*, the posterior margin of the valva is deeply emarginate, the sacculus long and slightly curved, and the median process of transtilla triangular, whereas in *A. atomosana* the posterior margin of the valva is acute, the sacculus short and rounded, and the median process of transtilla thumb shaped (Figs. 12b, 11b). In female genitalia, *A. matthewcruzi* has a small, round lamella postvaginalis and sternum 7 is not heavily sclerotized, whereas in *A. atomosana* the lamella postvaginalis is elliptical, and sternum 7 is heavily sclerotized (Figs. 12d, 11d). Sexual dimorphism in size may occur, as male FW length ranged 6.8–8.2 mm ( $n = 8$ ), and female, 8.6–9.2 mm ( $n = 4$ ). However, this might prove to be an artifact of small sample size.

**Discussion.** Females were associated by FW color pattern.

**Biology.** Larval foodplants unknown. June–August adult capture dates suggest a univoltine life cycle. Adults appear about one month earlier than those of *A. atomosana*. Although broadly sympatric with *A. atomosana*, *A. matthewcruzi* seems to occur in a wider variety of habitats.

**Etymology.** This species is named in memory of Matthew Edward Cruz, a talented young artist who lost his life in a tragic accident.

In conclusion, using male structural characters, we readily constructed a key to the 12 species treated, but it is omitted here because numerous untreated species of *Aethes* also occur in the region.

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# SYSTEMATICS OF MOTHS IN THE GENUS *CATOCALA* (NOCTUIDAE). III. THE TYPES OF WILLIAM H. EDWARDS, AUGUSTUS R. GROTE, AND ACHILLE GUENÉE

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**ABSTRACT.** Nomenclatural status is assessed for the 75 *Catocala* names authored by William Henry Edwards, Augustus Radcliffe Grote (including Coleman T. Robinson), and Achille Guenée. Three neotypes and 46 lectotypes are designated, and six new or revised synonymies are presented. Historical and biographical notes on these authors and the collections on which they based their descriptions are provided. Additionally, the unpublished *Catocala* paintings by the early North American naturalist John Abbot are analyzed in detail for the first time.

**Additional key words:** taxonomy, neotypes, lectotypes, collections, history, biography.

The holarctic genus *Catocala* Schrank (1802) is one of the most species-rich genera in the large moth family Noctuidae, with over 210 species split approximately equally between the Nearctic and Palearctic regions. Despite the fact that *Catocala* are large, colorful, and common moths that have been popular with lepidopterists for centuries, there has been no definitive systematic revision published for the entire genus, and the most current work treating all the Nearctic species is now approaching nearly a century old (Barnes & McDunnough 1918b; the most recent checklist covering the Nearctic taxa is Hodges et al. 1983).

The present paper is the last in a series on the taxonomy of the Nearctic *Catocala* appearing in advance of a Fascicle on the genus for the Moths of America North of Mexico. In the first two papers in the series (Gall 1990, Gall & Hawks 1990) we addressed 56 of the 347 names comprising the synonymy of the Nearctic *Catocala*, focusing on type material at the Field Museum of Natural History (Chicago) and the Museum of Comparative Zoology (Harvard University), and designating 32 lectotypes. Herein, we address 75 of the remaining Nearctic *Catocala* names authored by William H. Edwards, Augustus R. Grote, and Achille Guenée during the 19th century, designating 46 lectotypes and 3 neotypes, and establishing six new or revised synonymies and status amendments. Table 1 summarizes our taxonomic decisions.

This paper is divided into separate sections for Edwards, Grote, and Guenée, to highlight the biographical and type disposition issues particular to each author. Each section treats available names (species and subspecies) and then unavailable names (infrasubspecific entities such as “aberration”), respectively, in alphabetical order. Although names deemed to be infrasubspecific are unavailable under the International Code of Zoological Nomenclature (ICZN 2000), and

do not require formal treatment, we treat them here because we feel omitting them is a false economy that ultimately hampers revisory work, especially for groups like *Catocala* with lengthy and complex synonymies and historical literatures.

## NOMENCLATURAL PROTOCOL

The terms “form” and “variety” were used habitually in descriptions of new taxa by the Nearctic *Catocala* workers of the late 19th and early 20th centuries, and the tradition in the genus at that time was to apply these two terms in an infrasubspecific manner. However, without knowing this custom, it is often impossible to deduce infrasubspecific intent from the texts of the original descriptions alone, and the custom was certainly not applied universally. Fortunately, the earlier *Catocala* monograph by Barnes and McDunnough (1918b) and the lepidopteran checklists of Barnes and McDunnough (1917) and McDunnough (1938) indicate the availability previously deduced for such names. Because this complex and species-rich genus has never been fully revised, we opted to reassess availability for each “form” and “variety” name. The reason we did this is that infrasubspecific names, which are otherwise excluded from zoological nomenclature, become formally available if they are used later in a clearly subspecific or specific manner. In such instances, the name takes the date and authorship of the person(s) who used it at the elevated rank (see Articles 10.2 and 45.6 of the Code). Thus, if an original description of a *Catocala* suggested subspecific rank according to Article 45.6.4, but the Barnes and McDunnough monograph and checklists indicated that infrasubspecific rank had been previously deduced, we traced the name through the literature to insure that infrasubspecific usage had indeed been intended and had remained consistent. Discrepancies are treated in the accounts for individual names.



The terms “type” and “types” were also used in the majority of the original descriptions of Nearctic *Catocala*, often loosely. Because the texts for many of the descriptions could be termed telegraphic at best, we assumed the existence of syntypes when the singular “type” was used but the number of specimens was not otherwise readily and explicitly determinable. Often, type specimens for particular names were present in two or more institutional collections. We usually found evidence leading us to favor material from one institution, either on the basis of the descriptions per se, specimen labels, or related published information. The order of preference among institutional collections varies by author, and we discuss these and related idiosyncracies (e.g., missexed specimens) as appropriate. When we were unable to determine a precedence among available syntypes, we normally selected the specimen from the institution containing most of the author’s collection.

In most species of Nearctic *Catocala* there is complex individual variation in wing pattern, as well as parallel polymorphs that occur in both closely and more distantly related species. Largely because of this, a number of species boundaries among Nearctic *Catocala* remained poorly understood until our recent field and rearing studies covering the entire fauna. Moreover, many *Catocala* species are simply difficult to distinguish from one another, even when species’ boundaries are well known (indeed, a number of the syntypic series for names in this genus contain more than one *Catocala* species). These problems are especially manifest in the group of large, pink-hindwinged *Catocala* that feed as larvae on willows and poplars. The principal issue with the willow/poplar feeding taxa is that the extent of infrapopulational variation is far greater than previously understood. The group in fact consists of a much smaller array of species than indicated in the most recent faunal checklist by Hodges et al. (1983). A large number of the available names is referable to only five wide-ranging, morphologically variable, and difficult to separate Rocky Mountain and Pacific coast species: *faustina* Strecker, *hermia* Hy. Edwards, *californica* Edwards, *semirelict* Grote, and *junctura* Walker. Because these willow/poplar feeders also tend to have the most tangled nomenclatural histories, we feel it is imperative to fix all the involved names firmly. Thus, in this paper, we have designated a neotype for any available name that refers to a willow/poplar feeding taxon for which original type material is apparently no longer extant.

Nearctic *Catocala* type specimens are distributed in many institutional collections. However, the overwhelming majority of these types are at only eight in-

stitutions: the Academy of Natural Sciences of Philadelphia (ANSP), the American Museum of Natural History (AMNH), the Carnegie Museum of Natural History (CMNH), the Field Museum of Natural History (FMNH), the Museum of Comparative Zoology (MCZ), the Natural History Museum (London) (BMNH), the National Museum of Natural History (USNM), and the Yale Peabody Museum of Natural History (YPM). Types of *Catocala* are maintained in separate lepidopteran type collections at most of these institutions, but remain integrated with the general collections at others (e.g., the Strecker material at the FMNH, and the main historical series at the BMNH).

#### WILLIAM HENRY EDWARDS

W. H. Edwards was one of the most highly acclaimed American lepidopterists of the 19th century. His life and accomplishments have been well chronicled (see e.g., Mallis 1971), and he is probably best known for his monumental three-volume treatise *The Butterflies of North America*. W. H. Edwards was also the first American to focus on the Nearctic *Catocala*, naming a total of 10 new species in 1864.

During the 19th century, many of Edwards’ *Catocala* types apparently were extant in Philadelphia in the American Entomological Society collection, but by the time Beutenmüller was working on his revision of the genus, many of the types had vanished. Beutenmüller (1918a:44) stated: “These were supposed to be with the American Entomological Society, but I could not find them there nor in any other collection. I consequently wrote to W. H. Edwards shortly before his death [in 1909] asking for information on the matter and he informed me that all his *Catocala* went to Mr. Julius Meyer, Brooklyn, N.Y. After Mr. Meyer’s death his collection was bought by the Kny-Scheerer Co., New York, and Dr. G. Lagai writes me that the *Catocala* part of the same was sold to Hon. Walter Rothschild, Tring, London, England. If Edwards’ types are still extant the same will probably be found in the Rothschild collection.”

We have searched throughout the North American catocalines at the BMNH, and have not found any definite Edwards types in either the main systematic, Rothschild, or Oberthur collections. However, in the “Mixed Authors” type area at the BMNH is a drawer containing 34 specimens of 16 *Catocala* species, including representatives of each of the *Catocala* authored by Edwards, except for *similis* Edwards. The material in this drawer had been segregated out of the Rothschild collection. A single typed sheet accompanies this drawer, on which are listed Edwards’ and Meyer’s *Catocala* names, along with the statement:



TABLE 1. Synopsis of taxonomic assessments and actions taken in this paper pertaining to names in the moth genus *Catocala* Schrank. Institutional abbreviations are as listed in the text section Nomenclatural Protocol; additionally, RUPM = Roemer und Pelizaeus Museum, Germany, NYSM = New York State Museum, Albany. Note under the holotypes that a petition (Case 3210) is currently pending at the ICZN to suppress *polygama* Guenée, an unused senior synonym of *alabamae* Grote.

Taxon	Author	Date	Location	Rank assigned herein	Comments on rank
PREVIOUSLY DESIGNATED HOLOTYPES					
<i>arizonae</i>	Grote	1873	ANSP	synonym of <i>junctura</i> Walker (1858)	new synonymy
<i>beaniana</i>	Grote	1878	BMNH	synonym of <i>meskei</i> Grote (1873)	no change
<i>cara</i>	Guenée	1852	USNM	full species	no change
<i>clintoni</i>	Grote	1864	CMNH	full species	no change
<i>coelebs</i>	Grote	1874	BMNH	subspecies of <i>badia</i> Grote & Robinson (1866)	new status
<i>editha</i>	Edwards W. H.	1874	ANSP	synonym of <i>amatrix</i> (Hübner 1813)	new synonymy
<i>innubens</i>	Guenée	1852	USNM	full species	no change
<i>insolabilis</i>	Guenée	1852	USNM?	full species	no change
<i>lacrymosa</i>	Guenée	1852	USNM	full species	no change
<i>marmorata</i>	Edwards W. H.	1864	ANSP?	full species	no change
<i>messalina</i>	Guenée	1852	USNM?	full species	no change
<i>moderna</i>	Grote	1900	RUPM	synonym of <i>maestosa</i> Hulst (1884)	no change
<i>muliercula</i>	Guenée	1852	USNM?	full species	no change
<i>polygama</i>	Guenée	1852	USNM?	synonym of <i>grynea</i> (Cramer 1780)	no change
<i>uxor</i>	Guenée	1852	USNM?	synonym of <i>ilia</i> (Cramer 1780)	no change
PREVIOUSLY DESIGNATED NEOTYPES					
<i>californica</i>	Edwards W. H.	1864	CMNH	full species	no change
PREVIOUSLY DESIGNATED LECTOTYPES					
<i>adoptiva</i>	Grote	1874	MCZ	synonym of <i>delilah</i> Strecker (1874)	no change
<i>angusi</i>	Grote	1876	AMNH	full species	no change
NEOTYPES DESIGNATED HEREIN					
<i>connubialis</i>	Guenée	1852	BMNH	full species	no change
<i>micronympha</i>	Guenée	1852	AMNH	full species	no change
<i>walshii</i>	Edwards	1864	ANSP	synonym of <i>junctura</i> Walker (1858)	no change
LECTOTYPES DESIGNATED HEREIN					
<i>abbreviatella</i>	Grote	1872	ANSP	full species	no change
<i>alabamae</i>	Grote	1875	BMNH	full species	no change
<i>andromedae</i>	Guenée	1852	illustration	full species	no change
<i>androphila</i>	Guenée	1852	USNM	synonym of <i>amica</i> (Hübner 1813)	no change
<i>anna</i>	Grote	1874	BMNH	synonym of <i>amestris</i> Strecker (1874)	no change
<i>badia</i>	Grote & Robinson	1866	BMNH	full species	no change
<i>briseis</i>	Edwards W. H.	1864	ANSP	full species	no change
<i>cerogama</i>	Guenée	1852	USNM	full species	no change
<i>chelidonia</i>	Grote	1881	USNM	full species	no change
<i>coccinata</i>	Grote	1872	ANSP	full species	no change
<i>communis</i>	Grote	1872	ZMHU	synonym of <i>neogama</i> (J. E. Smith 1797)	no change
<i>desperata</i>	Guenée	1852	USNM	synonym of <i>vidua</i> (J. E. Smith 1797)	no change
<i>dulciola</i>	Grote	1881	AMNH	full species	no change
<i>febilis</i>	Grote	1872	ANSP	full species	no change
<i>formula</i>	Grote & Robinson	1866	ANSP	synonym of <i>similis</i> Edwards (1864)	no change
<i>fratercula</i>	Grote & Robinson	1866	ANSP	synonym of <i>micronympha</i> Guenée (1852)	revised synonymy
<i>frederici</i>	Grote	1872	ZMHU	full species	no change
<i>gracilis</i>	Edwards W. H.	1864	YPM	full species	no change
<i>habilis</i>	Grote	1872	ANSP	full species	no change
<i>levettei</i>	Grote	1874	BMNH	synonym of <i>judith</i> Strecker (1874)	no change
<i>lineella</i>	Grote	1872	BMNH	full species	no change
<i>melanympha</i>	Guenée	1852	USNM	synonym of <i>antinympha</i> (Hübner 1823)	no change
<i>meskei</i>	Grote	1873	USNM	full species	no change
<i>minuta</i>	Edwards W. H.	1864	YPM	full species	no change
<i>mira</i>	Grote	1876	BMNH	full species	no change
<i>palaeogama</i>	Guenée	1852	USNM	full species	no change
<i>parta</i>	Guenée	1852	USNM	full species	no change
<i>parvula</i>	Edwards W. H.	1864	ANSP	synonym of <i>minuta</i> Edwards (1864)	no change
<i>phalanga</i>	Grote	1864	BMNH	synonym of <i>palaeogama</i> Guenée (1852)	no change
<i>piatrix</i>	Grote	1864	CMNH	full species	no change



TABLE 1. Continued.

Taxon	Author	Date	Location	Rank assigned herein	Comments on rank
LECTOTYPES DESIGNATED HEREIN (Continued)					
<i>ponderosa</i>	Grote & Robinson	1866	BMNH	synonym of <i>nebulosa</i> Edwards (1864)	no change
<i>praeclara</i>	Grote & Robinson	1866	CMNH	full species	no change
<i>residua</i>	Grote	1874	AMNH	full species	no change
<i>retecta</i>	Grote	1872	ANSP	full species	no change
<i>robinsoni</i>	Grote	1872	ANSP	full species	no change
<i>scintillans</i>	Grote & Robinson	1866	BMNH	synonym of <i>innubens</i> Guenée (1852)	no change
<i>semirelecta</i>	Grote	1874	BMNH	full species	no change
<i>similis</i>	Edwards W.H.	1864	YPM	full species	no change
<i>simulatilis</i>	Grote	1874	BMNH	synonym of <i>obscura</i> Strecker (1873)	no change
<i>sinuosa</i>	Grote	1879	BMNH	subspecies of <i>coccinata</i> Grote (1872)	no change
<i>snowiana</i>	Grote	1876	AMNH	synonym of <i>palaeogama</i> Guenée (1852)	revised synonymy
<i>sordida</i>	Grote	1877	BMNH	full species	no change
<i>subnata</i>	Grote	1864	BMNH	full species	no change
<i>tristis</i>	Edwards W. H.	1864	ANSP	synonym of <i>andromedae</i> Guenée (1852)	revised synonymy
<i>verrilliana</i>	Grote	1875	BMNH	full species	no change
<i>westcottii</i>	Grote	1878	BMNH	synonym of <i>amestris</i> Strecker (1874)	no change
NO ACTION					
<i>basalis</i>	Grote	1876	BMNH	synonym of <i>habilis</i> Grote (1872)	infrasubspecific name
<i>bunkerii</i>	Grote	1876	BMNH	synonym of <i>cerogama</i> Guenée (1852)	infrasubspecific name
<i>flavidalis</i>	Grote	1874	BMNH	synonym of <i>innubens</i> Guenée (1852)	infrasubspecific name
<i>guenei</i>	Grote	1887	no type	replacement name for <i>viduata</i> Guenée (1852)	no change
<i>hilli</i>	Grote	1883	NYSM	synonym of <i>concumbens</i> Walker (1858)	infrasubspecific name
<i>nebulosa</i>	Edwards W. H.	1864	ANSP?	full species	no change
<i>serena</i>	Edwards W. H.	1864	ANSP?	full species	no change
<i>viduata</i>	Guenée	1852	no type	replacement name for <i>vidua</i> (J. E. Smith 1797)	no change

"The following are W. H. Edwards' species which Beutenmüller stated went to the Meyer Coll. and types ought to be in Tring." The typed sheet is undated, but almost certainly predates 1974 (M. Honey pers. com. 1999).

A type of *Catocala gisela* Meyer is in this drawer, and this suggests the material is indeed from Meyer, and is that referred to by Beutenmüller (1918a). The representative specimens of Edwards' species in the drawer all bear labels in what appears to be A. Rogenhofer's handwriting, giving the collecting locality and other details, as well as stating "Type." However, the label data on most of these supposed Edwards types do not correspond to what appears in the respective original descriptions by Edwards. For example, the specimen of *Catocala marmorata* Edwards is labelled "Ky." (=Kentucky) whereas the original description calls for Yreka, California, and its abdomen is also intact, contradicting Strecker (1874:73), who figured the *marmorata* type and stated that the "abdomen is wanting in the single example so far known;" the specimen of *Catocala briseis* Edwards is labelled "Canada" whereas the original description calls for one specimen from the Catskills [New York] and one specimen from

Rhode Island, and both of these two syntypes have already been located in other collections; and so forth. Thus, we feel these BMNH specimens are not Edwards' types, but rather are specimens that were considered to be typical, or compared to the types (or perhaps even asserted to be types during the several transfers of Edwards' material, to enhance their monetary value).

Although Beutenmüller (1918a) indicated he could not find Edwards' *Catocala* types at the ANSP, we readily located one of his two *briseis* syntypes in the main ANSP collection that apparently had not previously been segregated into the type cabinets. We have also explored the CMNH collection for possible Edwards *Catocala* types, with limited success (see our notes on the ANSP and CMNH below under A. R. Grote). Another collection known to have been utilized heavily by Edwards, Grote, and Strecker in the 1860's and 1870's was that of Mrs. Bridgham, from Rhode Island. In 1991, the senior author located the Bridgham family's collection at the Smithfield branch of the Audubon Society of Rhode Island, and its specimen material was transferred to the Yale Peabody Museum of Natural History in 1992 (about 1800 specimens were





FIG. 1. Type specimens of moths in the genus *Catocala* Schrank. W. H. Edwards types. **a**, lectotype, *briseis*. **b**, neotype, *californica*. **c**, lectotype, *gracilis*. **d**, lectotype, *minuta*. **e**, lectotype, *parvula*. **f**, lectotype, *similis*. **g**, lectotype, *tristis*. **h**, neotype, *walshii*. 0.9–1.0 × natural size.

salvaged, and the Victorian-era cabinet remained with the Audubon Society; Gall 1995). A number of the Bridgham specimens bear Grote determination labels, and syntypes for all *Catocala* species that Edwards (1864) cited explicitly as coming from the Bridgham collection were extant and identifiable. The Bridgham collection is almost unquestionably an uncited source for all *Catocala* that Edwards authored that are native to the eastern USA. Our procedure for W. H. Edwards' names is therefore to give precedence first to type material from any explicitly cited collection, then to Bridgham (YPM), and then to ANSP/CMNH.

Available Names

*Catocala briseis* W. H. Edwards, 1864. Proc. Entomol. Soc. Phil. 2:508

The original description states “I have seen but two individuals of this species, one of which was taken by me in the Catskills in July, 1861; the other is in the fine collection of Mrs. Bridgham, taken in Rhode Island.” One unlabeled male ex Bridgham collection is at the YPM, and a female labeled as *briseis* by Edwards is at the ANSP. We give precedence to the labeled ANSP female, and to clarify application of the name we



hereby designate it as LECTOTYPE for *briseis* (Fig. 1a). The lectotype bears the labels “briseis” and “LECTOTYPE/*Catocala briseis*/Edwards 1864/Desig. Gall & Hawks 2002.” The type locality is hereby restricted to the Catskill [Mountain]s, [New York, USA]. We recognize *Catocala briseis* as a full species.

*Catocala californica* W. H. Edwards, 1864. Proc. Entomol. Soc. Phil. 2:509

The original description does not state the number of types. Although Strecker claimed to have figured the type of *californica*, Barnes and McDunnough (1918b:24–25) provided credible evidence that Strecker’s specimen was not from the type series. They also located a specimen at the CMNH with suitable locality data “which proved to be what has generally been known as *mariana* [Hy.] Edwards,” and stated “We propose, therefore, to consider this specimen as typifying the true *californica* and list *mariana* as a synonym.” We consider Barnes and McDunnough’s discussion and subsequent proposal to constitute a valid neotype designation for *californica*, meeting the criteria listed in Article 75 of the Code. We show their neotype in Fig. 1b. The type locality is Yreka, [Siskiyou County,] California [USA]. We recognize *Catocala californica* as a full species.

*Catocala editha* W. H. Edwards, 1874. Trans. Amer. Entomol. Soc. 5:112

The original description states “a single specimen taken in Sonoto Valley, by Mr. Henshaw, July, 1874.” This specimen, the holotype by monotypy, is at the ANSP (ANSP Type #7719). The type locality is Sonoto Valley, [Arizona, USA]. The name *editha* has previously been tabulated in the Nearctic literature as a subspecies of *Catocala amatrix* (Hübner, [1813]). However, the *editha* holotype falls within the normal range of variation seen in nominate *amatrix* from elsewhere in North America (the infrasubspecific form “pallida” Barnes & McDunnough (1918b), with silvery-white forewing shading and a reduced hindwing medial band, is usually listed as a synonym of *editha*; specimens of “pallida” occur sporadically in the western Plains states and more consistently in the Rocky Mountains). We recognize *Catocala editha* as a synonym of *Catocala amatrix* (Hübner) (NEW SYNONYMY).

*Catocala gracilis* W. H. Edwards, 1864. Proc. Entomol. Soc. Phil. 2:511

The original description does not state the number of types, but indicates “Mrs. Bridgham’s Collection.” A series of 12 *gracilis* ex Bridgham collection is at the

YPM. One male bears a handwritten label “gracilis? Edw.” in Grote’s handwriting, unquestionably dating from around the time of Grote’s stated uncertainty about the name (Grote 1877:169–170). To clarify application of the name we hereby designate this male as LECTOTYPE for *gracilis* (Fig. 1c). In addition to the above label, the lectotype bears the labels “Samuel Willard Bridgham/Collection/Presented Rhode Island/Audubon Society, May 1992” and “LECTOTYPE/*Catocala gracilis*/Edwards 1864/Desig. Gall & Hawks 2002.” The type locality is not specified, but is probably Rhode Island, USA. We recognize *Catocala gracilis* as a full species.

*Catocala marmorata* W. H. Edwards, 1864. Proc. Entomol. Soc. Phil. 2:508

Of the type of *marmorata*, Strecker (1874:73) rather amusingly stated “abdomen is wanting in the single example so far known . . . the unique type from which the annexed figure was drawn is in the Museum of the Am. Ent. Soc.; its sex can not be determined, as, unfortunately, the abdomen, as I before stated, is non est, but from the general appearances I should suppose the example in question to be a ♀.” Subsequently, Barnes and McDunnough (1918b:20) offered: “at the present time it is misplaced or lost . . . Fortunately, Strecker’s figure leaves no doubt as to the identity.” We have not been able to locate this specimen at the ANSP, and the specimen of *marmorata* in the box of supposed W. H. Edwards types at the BMNH has an abdomen and bears the label “Ky.,” contradicting the stated type locality of Yreka, California. The original description did not state the number of types, but it seems clear from the early literature accounts that only one specimen was known at the time. We therefore accept the specimen figured by Strecker (1874, Plate IX, Fig. 6) as the holotype by monotypy for *marmorata*. The type locality of Yreka, California [USA] is erroneous, since *marmorata* has a well-defined distribution from the mid-Atlantic states west to Missouri and Arkansas (Peacock & Gall 2001). We recognize *Catocala marmorata* as a full species.

*Catocala minuta* W. H. Edwards, 1864. Proc. Entomol. Soc. Phil. 2:512

The original description does not state the number of types, but indicates “Mrs. Bridgham’s Collection. New York.” There are two specimens of *minuta* ex Bridgham collection at the YPM. One male bears a label “minuta/Ed.?” in Grote’s handwriting, and another bears a label “undescribed A,” apparently in Edwards’ handwriting. These correspond to *minuta* and its undescribed variety in Edwards’ description, and we



hereby designate the male with Grote's label as LECTOTYPE for *minuta* (Fig. 1d). In addition to the above label, the lectotype bears the labels "Samuel Willard Bridgham/Collection/Presented Rhode Island/Audubon Society, May 1992" and "LECTOTYPE/*Catocala minuta*/Edwards 1864/Desig. Gall & Hawks 2002." The type locality is New York [USA]. We recognize *Catocala minuta* as a full species.

*Catocala nebulosa* W. H. Edwards, 1864. Proc. Entomol. Soc. Phil. 2:510

The original description does not state the number of types, nor the collection from which Edwards made his description, indicating only "Philadelphia; Washington." There are no *nebulosa* ex Bridgham collection at the YPM. At the ANSP collection are two old, unlabeled male *Catocala nebulosa*. However, we are not certain that these ANSP specimens were among those available to Edwards. Since the original description of *nebulosa* is diagnostic, and there has been no confusion as to the applicability of the name, we choose not to take any formal action. We recognize *Catocala nebulosa* as a full species.

*Catocala parvula* W. H. Edwards, 1864. Proc. Entomol. Soc. Phil. 2:512

The original description does not state the number of types, nor the collection from which Edwards made his description. At the ANSP collection is an old male bearing a label "C. minuta/v. parvula," pinned in a distinctive style that matches that of other *Catocala* labeled as types at the ANSP. To clarify application of the name, we hereby designate this male as LECTOTYPE for *parvula* (Fig. 1e). The lectotype bears the aforementioned label and "LECTOTYPE/*Catocala parvula*/Edwards 1864/Desig. Gall & Hawks 2002." The type locality is New York [USA]. The name *parvula* is a synonym of *Catocala minuta* Edwards, and represents specimens with a large dark patch along the forewing inner margin.

*Catocala serena* W. H. Edwards, 1864. Proc. Entomol. Soc. Phil. 2:510

The original description does not state the number of types, but indicates "From Mr. Wilt's collection, Philadelphia." There are several old specimens of *serena* at the ANSP, as well as at the CMNH, but we are not certain these were among the specimens available to Edwards. Since the original description of *serena* is diagnostic, and there has been no confusion as to the applicability of the name, we choose not to take any formal action. We recognize *Catocala serena* as a full

*Catocala similis* W. H. Edwards, 1864. Proc. Entomol. Soc. Phil. 2:511

The original description does not state the number of types, but indicates "Mrs. Bridgham's Collection." Three specimens of *similis* ex Bridgham collection are at the YPM, and to clarify application of the name we hereby designate a male as LECTOTYPE for *similis* (Fig. 1f). The lectotype bears the labels "Samuel Willard Bridgham/Collection/Presented Rhode Island/Audubon Society, May 1992" and "LECTOTYPE/*Catocala similis*/Edwards 1864/Desig. Gall & Hawks 2002." The type locality is not specified, but is probably Rhode Island, USA. We recognize *Catocala similis* as a full species.

*Catocala tristis* W. H. Edwards, 1864. Proc. Entomol. Soc. Phil. 2:511

The original description does not state the number of types, but indicates "From Mr. Newman's collection, taken at Philadelphia; also Mr. Jung's collection, at Hoboken, New Jersey." There is an old male at the ANSP, pinned in a distinctive style matching other *Catocala* labeled as types at the ANSP. To clarify application of the name, we hereby designate this male as LECTOTYPE for *tristis* (Fig. 1g). The lectotype bears the label "LECTOTYPE/*Catocala tristis*/Edwards 1864/Desig. Gall & Hawks 2002." The type locality can not be specified further. Although Forbes (1954) treated *tristis* as a synonym of *Catocala andromedae* Guenée (1852), Hodges et al. (1983) re-elevated *tristis* as a northern subspecies of *andromedae*. The differences cited for *tristis* are indeed not geographically definable, as Forbes implied, and so we hereby place *tristis* as a synonym of *andromedae* (REVISED SYNONYMY).

*Catocala walshii* W. H. Edwards, 1864. Proc. Entomol. Soc. Phil. 2:509

The original description does not state the number of types, and indicates "Taken by Mr. B. D. Walsh in Southern Illinois." Grote (1873:163) stated that the species "is still unknown to me. I believe the types perished in the Chicago fire," and Smith (1893) apparently followed him in stating the types were destroyed. However, the 14 February 1879 minutes of the *Proceedings of the Monthly Meetings of the Entomological Section of the Academy of Natural Sciences, Philadelphia* indicate (Anonymous 1879:iii): "Mr. Cresson exhibited the type specimens of *Catocala editha* Edwards, and *Catocala walshii* Edwards, which had been sent to him by Mr. William H. Edwards, for the collection of the American Entomological Society." There



are several old specimens at the ANSP and CMNH labeled as *walshii*, but we can not say for certain which of these might be the Cresson specimen(s).

The type locality of southern Illinois suggests *walshii* refers to *Catocala junctura* Walker, the only large *Catocala* species in that geographic region that matches the original description, and *walshii* has been treated as a synonym of *junctura* since Barnes and McDunnough (1918b:29). However, because (a) we have been unable to locate a type, (b) other published type localities of Edwards are erroneous, and (c) a willow/poplar feeding taxon is involved, we feel the name *walshii* requires explicit clarification. We therefore designate a male from among the aforementioned specimens at the ANSP as NEOTYPE for *walshii* (Fig. 1h). The neotype bears the label "Catocala/walshii" and "NEOTYPE/*Catocala walshii*/Edwards 1864/Desig. Gall & Hawks 2002." The type locality is southern Illinois [USA]. The name *walshii* is a synonym of *Catocala junctura* Walker.

#### AUGUSTUS R. GROTE

Augustus Radcliffe Grote was one of the foremost authorities on Nearctic moths in the 19th century. He published profusely throughout the Noctuidae, and authored 45 Nearctic *Catocala* names, more than any other worker. His earliest *Catocala* descriptions were published in 1864 and 1866 (with Coleman T. Robinson), and in 1872, Grote presented the first revision of the entire Nearctic *Catocala* fauna in the *Transactions of the American Entomological Society*. This revision would doubtless have been even more comprehensive, if it were not for the fact that Grote apparently lost the original manuscript for it.

Grote described new species from specimens in a wide array of personal and institutional collections, and hence his types are known to be widely scattered. The BMNH purchased most of Grote's collection in 1881/1882, and this is the principal repository of his type material. For Grote *Catocala* types, the ANSP is as important as the BMNH, as Grote remarked in his 1872 revision that "most of the material I have used is in the collection of the American Entomological Society, together with Mr. Edwards' specimens kindly loaned me for examination."

Although we located types for most Grote names fairly readily, we encountered some difficulties tracking down types from his earliest publications, notably the *Catocala* he authored with C. T. Robinson. This is hardly a novel situation, as lepidopteran systematists have speculated for some time on the whereabouts of apparently lost Grote and Robinson types. Beutenmüller (1892) provides an accounting of Lepidoptera

types known to be at the AMNH from the Grote and Robinson collection, but no *Catocala* are included in that list. Smith's (1893:12) discussion is instructive: "Mr. Grote writes concerning the work by Mr. Robinson and himself: 'The collection on which these and all our other joint entomological writings were based, is now in the possession of the American Entomological Society.' If that was true in 1872, it certainly is not so now, because but a very few of the species are at present in that collection. Of these, a very small proportion only have a written label. Some have a little printed 'type' label; but nothing to indicate of what it is the type. In at least two cases I found these 'type' specimens under names with which they had no possible relationship. Fortunately the excellent figures given in illustration of the papers referred to, make it possible to ascertain the names of which the specimens are typical. But many species have disappeared, leaving no trace; in whose hands they are at present I have been unable to ascertain."

Grote moved to Germany in 1884 after the sale of his collection to the BMNH, living first in Bremen and then later in Hildesheim until his death in 1903. He was actively collecting while at Hildesheim (e.g., Grote 1897, Stein 1999), and Horn and Kahle (1935:97) indicated that Grote's material was also deposited "ex parte 1893 an Mus. Bremen." Since it seemed possible that the missing Grote and Robinson material to which Smith (1893) referred could be in Germany, we visited the Museum für Naturkunde of Humboldt University in Berlin (ZMHU), the Übersee-Museum in Bremen and the Roemer- und Pelizaeus Museum in Hildesheim in April 2000 to search for types. We were able to review the entire lepidopteran holdings of the Roemer Museum, all the Nearctic Lepidoptera at the Übersee Museum, but only the catocalines at ZMHU. The ZMHU has 24 drawers of *Catocala*, and it contains the types for two Grote *Catocala* species that he explicitly indicated were in that institution, as well as a number of specimens that he and Robinson determined. The Übersee Museum collection has 4 drawers of Grote's Nearctic Lepidoptera, two drawers of which are exclusively *Catocala*, but no types. The Roemer Museum collection, presently housed at the Biology Department of Hildesheim University, has 13 drawers of Grote's Nearctic Lepidoptera, several of which contain *Catocala*, including the type of *Catocala moderna* Grote (as stated in the original description). The Roemer also has the Palearctic Lepidoptera that Grote assembled from Hildesheim and surrounding areas.

We have also examined the Lepidoptera collection at the Buffalo Museum of Science, which contains the holdings from the Buffalo Society of Natural History,



with which Grote was affiliated during the 1870's when he lived in Buffalo. We found no Grote *Catocala* types there. Arnett et al. (1993:209) state that "major portions of [Grote's] collection were given to the Museum of Natural History (BMNH) and to the Museum of Natural History of Sao Paulo," and thus Brazil is the only other potential repository for Grote and Robinson material of which we are aware. Insofar as *Catocala* are concerned, the Museu de Zoologia in Sao Paulo currently has only a small number of specimens, representing common Nearctic and Palearctic species. Among the Sao Paulo specimens are one *cara* Guenée, one *concumbens* Walker, and one *ilia* (Cramer), all bearing Grote determination labels in his handwriting (C. R. F. Brandao pers. com. 1999).

At this juncture we believe that the missing lepidopteran types of Grote and Robinson are probably not extant in Germany, and we are more confident still that this is the case for their *Catocala* types. In sum, then, definitive and probable type material for the *Catocala* authored by Grote, as well as Grote and Robinson, exist in the collections of the ANSP, BMNH, AMNH, ZMHU, CMNH and at Hildesheim University. The presence at CMNH of Grote *Catocala* is the result of an extensive exchange of material between ANSP and CMNH in the 1960's, that sent Lepidoptera from ANSP to CMNH, and Orthoptera from CMNH to ANSP (J. Rawlins pers. com. 1999). At CMNH, these former ANSP specimens are identifiable by labels indicating they were part of CMNH accession 20359.

In most instances, Grote types in the aforementioned institutional collections bear one or more labels indicating they are types, although this is not universally so (e.g., the BMNH holotype of *Catocala inubens* var. *flavidalis* Grote, mentioned by Beutenmüller 1903b). The label situation at the BMNH, where the bulk of Grote's collection resides, merits further elaboration. Many of Grote's *Catocala* types at the BMNH have apparently been identified as such by A. G. Butler (or his curatorial contemporaries), whose habit was to write the taxon name and the word "type" on the reverse of the attached BMNH accession label (M. Honey pers. com. 1991). Typically, these types also bear a red-bordered label with the taxon name followed by the word "type," handwritten by Grote. Most of Grote's other *Catocala* specimens at the BMNH bear no type labels, but a small number of these other specimens bear blue-bordered labels with only the taxon name, again in Grote's handwriting (in at least some other noctuid groups, Grote's habit appears to have been to use a red-bordered label when one type existed, and a blue-bordered label when more than

one existed; E. Quinter pers. com. 2001). The blue-bordered labels often appear on single exemplars of *Catocala* named by Grote in the 1870's, and by Grote and Robinson in 1866 (one such specimen of *scintillans* Grote & Robinson is also labeled as type by Butler, the only blue-bordered Grote & Robinson taxon so labeled at the BMNH). A few specimens with the blue-bordered labels also bear the red-bordered type labels: for example, the type of *sinuosa* Grote, named in 1879, and the types of *coelebs* Grote and *semirelecta* Grote, both of which were named in 1874. Based on the distribution of these red and blue-bordered labels among the BMNH *Catocala*, we believe that specimens bearing such labels were among those on which Grote based his type concepts, and so we treat them all as available type material.

We also note here that the two published listings of Nearctic *Catocala* types at the BMNH (Beutenmüller 1903a, Hampson 1913; both were prepared by Hampson) are not concordant. The former tabulates 27 taxa, the latter 31 taxa. There are 25 taxa common to both the 1903 and 1913 listings. Six taxa appear only in the 1913 listing (*beaniana* Grote, *crataegi* Saunders, *electilis* Walker, *nurus* Walker, *selecta* Walker, *subnata* Grote), and two appear only in the 1903 listing (*bunker*i Grote, *sordida* Grote). In addition, the types of *albomacula* Butler, *flavidalis* and *scintillans* Grote & Robinson are omitted from both the 1903 and 1913 listings, despite the fact that the main collection at the BMNH has specimens of each that bear type labels written by Butler. Because of these omissions, the dropping of *bunker*i and *sordida* between 1903 and 1913, and the inconsistent tabulation of the Walker types (these had long since been established e.g., see Grote & Robinson 1868), we view with some reservation Hampson's compilations of type specimens of Nearctic *Catocala* at the BMNH.

Thus, our approach for Grote *Catocala* is to give precedence first to specimens having the most appropriate label data in the most appropriate collections, and then to the BMNH and ANSP/CMNH collections, in that order. However, for taxa described in Grote's (1872) revision, the ANSP/CMNH is given initial precedence. For taxa for which we failed to locate a labeled type, we choose BMNH specimens with blue-bordered Grote labels, if possible. Although the published type localities for Grote names usually match data on the specimen labels, this is not universally so. The most common mismatches involve the handwritten locality data that were added subsequently to the printed "Grote Coll./81-116" accession labels by BMNH curatorial staff. In such instances, we give precedence to Grote's published type localities.





FIG. 2. Type specimens of moths in the genus *Catocala* Schrank. A. R. Grote types (authorship is Grote unless otherwise noted). **a**, lectotype, *abbreviatella*. **b**, lectotype, *alabamae*. **c**, lectotype, *anna*. **d**, lectotype, *badia* Grote & Robinson. **e**, lectotype, *coccinata*. **f**, lectotype, *chelidonia*. **g**, lectotype, *dulciola*. **h**, lectotype, *formula* Grote & Robinson. **i**, lectotype, *communis*. **j**, lectotype, *flebilis*. 0.9–1.0 × natural size.

#### Available Names

*Catocala abbreviatella* Grote, 1872. Trans. Amer. Entomol. Soc. 4:14

The original description states “♂♀ . . . Two specimens from Texas (Belfrage).” There are only two *abbreviatella* at the ANSP, one male and one female,

both old and bearing no labels but pinned in a similar manner. In Drawer 25 at the BMNH is one male bearing a conflicting locality label of “Kansas.” The pair at the ANSP appear to be the syntypes, and to clarify application of the name we hereby designate the male as LECTOTYPE for *abbreviatella* (Fig. 2a). The lectotype bears the label “LECTOTYPE/*Catocala abbrevi-*



*atella*/Grote 1872/Desig. Gall & Hawks 2002." The type locality is Texas [USA]. We recognize *Catocala abbreviatella* as a full species.

*Catocala alabamae* Grote, 1875b. Proc. Acad. Nat. Sci. Phil. 27:427

The original description does not state the number of types. In Drawer 29a at the BMNH is a female labeled as type by Grote, bearing a red BMNH type disc. To clarify application of the name we hereby designate it as LECTOTYPE for *alabamae* (Fig. 2b). The lectotype bears the labels "Ala.", "Alabama/Grote Coll./81-116.", "Alabama/81-116 [and on the reverse:] *Catocala/alabamae*/Type Grote", "*Catocala alabamae*/Type Grote", "LECTOTYPE/*Catocala alabamae*/Grote 1875/Desig. Gall & Hawks 2002." The type locality is Demopolis, [Marengo County,] Ala[bama, USA]. We recognize *Catocala alabamae* as a full species.

*Catocala adoptiva* Grote, 1874c. Trans. Amer. Entomol. Soc. 5:96.

The male lectotype is at the MCZ, and was designated by Gall (1990:121). The type locality is Dallas Co[unty], Texas, [USA]. We recognize *Catocala adoptiva* as a synonym of *Catocala delilah* Strecker.

*Catocala angusi* Grote, 1876a. Can. Entomol. 8:229

We consider Beutenmüller's (1907:150) action to constitute a valid lectotype designation for *angusi* under Article 74 of the Code. The male lectotype is at the AMNH. The type locality is West Farms, New York City [Bronx County, USA], fide Beutenmüller's statements. We recognize *Catocala angusi* as a full species.

*Catocala anna* Grote, 1874c. Trans. Amer. Entomol. Soc. 5:96

The original description states "Texas. (Boll. No. 104)." In Drawer 25 at the BMNH is a male labeled as *anna* by Grote, but not as type. An identically labeled male is at the ANSP. A total of five other new *Catocala* were described by Grote in the article in which *anna* appeared, and the types for these five other taxa are at the BMNH. We thus give precedence to the BMNH specimen in Drawer 25, and to clarify application of the name designate it as LECTOTYPE for *anna* (Fig. 2c). The lectotype bears the labels "anna Grote", "U. S. America/Grote Coll./81-116.", "United States/81-116 [and on the reverse:] *Catocala/anna*/Grote", "*Catocala/anna*/Grote", "LECTOTYPE/*Catocala anna*/Grote 1874/Desig. Gall & Hawks 2002." The type locality is Texas [USA]. The name *anna* is a synonym of *Catocala amestris* Strecker.

*Catocala arizonae* Grote, 1873. Can. Entomol. 5:163

The original description states "I have received this species from Professor Townend Glover, of the Agricultural Department at Washington. It is labelled 'Borders of Arizona and New Mexico.—Dr. Palmer.'" This male, the holotype by monotypy, is at the ANSP (ANSP Type #7659). The type locality is the border of Arizona and New Mexico [USA]. The type of *arizonae* is a specimen of *Catocala junctura* Walker, and we hereby place *arizonae* as a synonym of *junctura* (NEW SYNONYMY).

*Catocala badia* Grote & Robinson, 1866. Proc. Entomol. Soc. Phil. 6:22

The original description states "Numerous coincident specimens from Massachusetts, Rhode Island, New York and Pennsylvania examined." Among five old specimens at the ANSP is a female bearing the machine-printed labels "Mass." and "Coll. of Acad./Nat. Sci. Phila." A male in Drawer 3a at the BMNH bears a blue-bordered Grote label. We give precedence to the BMNH specimen, and to clarify application of the name we hereby designate this male as LECTOTYPE for *badia* (Fig. 2d). The lectotype bears the labels "U. S. America/Grote Coll./81-116.", "United States 81-116 [and on the reverse] *Catocala/badia*/Gr. + Rob.", "*Catocala Schrank/badia* G + R.", "LECTOTYPE/*Catocala badia*/Grote & Robinson 1866/Desig. Gall & Hawks 2002." The type locality cannot be restricted further. We recognize *Catocala badia* as a full species.

*Catocala beaniana* Grote, 1878. Can. Entomol. 10:195

The original description states "Sent me by Mr. Thomas A. Bean, under the number 574, from Illinois." This female, the holotype by monotypy, is in Drawer 18 at the BMNH. The type locality is Illinois [USA]. The name *beaniana* is a synonym of *Catocala meskei* Grote.

*Catocala chelidonia* Grote, 1881c. Papilio 1:159

The original description states "♂♀ . . . Numerous specimens of this very distinct form in the collection [Neumoegen] before me." A male type is at the USNM, and to clarify application of the name we hereby designate it as LECTOTYPE for *chelidonia* (Fig. 2f). The lectotype bears the labels "Prescott/Arizona.", "Type No./33987/U.S.N.M.", "TYPICUM/SPECIMEN", "*Catocala Type/chelidonia*/Grote", "LECTOTYPE/*Catocala chelidonia*/Grote 1881/Desig. Gall & Hawks 2002." The type locality is Prescott, [Yavapai County,] Arizona [USA]. We recognize *Catocala chelidonia* as a full species.



*Catocala clintoni* Grote, 1864a. Proc. Entomol. Soc. Phil. 3:89

The original description states “Hab. Eastern States. A ♀ specimen in good condition given me by Mr. Wm. A. Nason, and now in the Coll. Ent. Soc. Philadelphia.” There are four *clintoni* in the ANSP collection, two with locality labels indicating Kansas and two indicating Texas, none of which match the locality of “Eastern States.” In Drawer 23 at the BMNH is a female *clintoni* from New York, ex Grote collection. An old female *clintoni* at the CMNH bears a label indicating it came from accession 20359. We know that at least one type of *praeclara* Grote & Robinson ended up at CMNH as part of the CMNH/ANSP exchange on accession 20359. Because Hampson (1913) and Beutenmüller (1903a) omit *clintoni* from their lists of Nearctic *Catocala* types at the BMNH, and because the original description calls for the ANSP, we believe that the CMNH specimen is more probably the holotype by monotypy. The type locality is Eastern States [USA]. We recognize *Catocala clintoni* as a full species.

*Catocala coccinata* Grote, 1872. Trans. Amer. Entomol. Soc. 4:6

The original description states “♂♂ . . . My specimens are from Pennsylvania.” A male type is at the ANSP, and to clarify application of the name we hereby designate it as LECTOTYPE for *coccinata* (Fig. 2e). The lectotype bears the labels “Penn.,” “TYPE No. 7663/Catocala/coccinata/A. R. Grote,” “C. coccinata/Grote/A.R.G.,” “LECTOTYPE/Catocala coccinata/Grote 1872/Desig. Gall & Hawks 2002.” The type locality is Pennsylvania [USA]. We recognize *Catocala coccinata* as a full species.

*Catocala coelebs* Grote, 1874c. Trans. Amer. Entomol. Soc. 5:96

The original description states “St. Catherines, August 18, No. 182, Geo. Norman Esq.” This female, the holotype by monotypy, is in Drawer 4 at the BMNH. The type locality is S[ain]t Catherines, [Regional Municipality of Niagara, Ontario, Canada].

*Catocala coelebs* and *Catocala badia* Grote & Robinson have been treated for some time as closely related, distinct species. Largely monomorphic populations referable to *badia* occur along the eastern seaboard from south central Massachusetts through New Jersey and Pennsylvania; similarly monomorphic populations referable to *coelebs* occur from the Maritime Provinces of Canada through Maine and northern New England, and westward to

northern Michigan, Wisconsin and the Prairie Provinces of Canada. However, the geographic ranges of these “pure” *badia* and “pure” *coelebs* populations are essentially parapatric—a small zone of overlap exists in New Hampshire, southern Maine, and northern coastal Massachusetts in which specimens with intermediate forewing patterns occur. These have been named *badia* form *phoebe* Hulst.

We have examined large series of *badia* and *coelebs* from the entire geographic range of both taxa, particularly in the zone of overlap in New England, and find no consistent way to distinguish material in the overlap area. Although we have reared a number of broods of “pure” *badia* from Connecticut and southern Massachusetts, and “pure” *coelebs* from northern Maine and Michigan, eggs from a female *coelebs* taken in southern York County, Maine produced progeny referable to both *coelebs* (several dozen adults) and *phoebe* (three adults) and intergrades. We have also found no constant differences between *badia* and *coelebs* in their larvae or the scanning electron micrograph patterns of their eggs. However, the larvae and eggs of *badia/coelebs* are separable from those of the two other closely related Nearctic Myricaceae-feeding species, *antinympha* (Hübner) and *muliercula* Guenée; in turn, the larvae of *antinympha* and *muliercula* are also separable from one another.

Accordingly, we feel the observed geographic variation in *badia* and *coelebs* is more indicative of two distinct subspecies, and we hereby place the name *coelebs* as a subspecies of *Catocala badia*, **new status**. Grote, who described both *badia* and *coelebs*, had arrived at an essentially similar conclusion (1883a:23): “But a sight of many specimens leads me to believe that the true *C. coelebs*, with black fore wings, grades into *badia*, and is only to be regarded as a variety of it. But this could not have been predicated of the type [of *coelebs*]. The two extremes are exceedingly distinct and different looking.”

*Catocala communis* Grote, 1872. Trans. Amer. Entomol. Soc. 4:9

In a discussion of *Catocala neogama* J. E. Smith, Grote stated (1872:9) “I do not believe this [*neogama* sensu Guenée] to be the *Phalaena neogama* of Smith. In the Berlin Museum I have named this species *Catocala communis*, while two specimens from Texas therein contained differed from the present by their brighter colored secondaries, and otherwise more nearly resembled Abbot’s figure [of *neogama* J. E. Smith].” A male type is in Drawer 155 at the Museum für Naturkunde of Humboldt University in Berlin



(ZMHU), and to clarify application of the name we hereby designate it as LECTOTYPE for *communis* (Fig. 2i). The lectotype bears the labels "10918", "communis/Grote & Rob./neogama Guen./ (non Sm.-Abb.)/Carolina [unintelligible]", "7158", "LECTOTYPE/*Catocala communis*/Grote 1872/Desig. Gall & Hawks 2002." The type locality is hereby restricted to [North or South] Carolina, [USA] on the basis of the lectotype label. The name *communis* is a synonym of *Catocala neogama* J. E. Smith.

*Catocala dulciola* Grote, 1881a. Papilio 1:5

The original description states "Five or six examples, all alike, have been collected by Mr. Pilate . . . The female type before me expands 44 millimetres." A female type is at the AMNH, and to clarify application of the name we hereby designate it as LECTOTYPE for *dulciola* (Fig. 2g). The lectotype bears the labels "Catocala ♀ Type/dulciola Grote", "No. 11742 H. Edw.", "Type No. AMNH", "Catocala/dulciola/Grote", "LECTOTYPE/*Catocala dulciola*/Grote 1881/Desig. Gall & Hawks 2002." The type locality is the vicinity of Dayton, [Montgomery County], Ohio [USA]. We recognize *Catocala dulciola* as a full species.

*Catocala flebilis* Grote, 1872. Trans. Amer. Entomol. Soc. 4:4

The original description states "Several specimens examined from Pennsylvania." A male type is at the ANSP, and to clarify application of the name we hereby designate it as LECTOTYPE for *flebilis* (Fig. 2j). The lectotype bears the labels "Penn.", "TYPE No. 7665/Catocala/flebilis/A. R. Grote", "C. flebilis/Grote/A.R.G./Type", "LECTOTYPE/*Catocala flebilis*/Grote 1872/Desig. Gall & Hawks 2002." The type locality is Pennsylvania [USA]. We recognize *Catocala flebilis* as a full species.

*Catocala formula* Grote & Robinson, 1866. Proc. Entomol. Soc. Phil. 6:27

The original description states "A number of specimens of both sexes examined. Habitat—New York State, Rhode Island. Coll. Ent. Soc. Phila.; our own Collection and that of Mrs. S. W. Bridgham, N. Y." A male type is at the ANSP, and to clarify application of the name we hereby designate it as LECTOTYPE for *formula* (Fig. 2h). The lectotype bears the labels "N. Y.", "TYPE No. 7662/Catocala/formula/A. R. Grote & Rob.", "C. formula G + R", "LECTOTYPE/*Catocala formula*/Grote & Robinson 1866/Desig. Gall & Hawks 2002." The type locality is hereby restricted to New York [USA] on the basis of the lectotype locality label. The name *formula* is a synonym of *Catocala similis* Edwards.

*Catocala fratercula* Grote & Robinson, 1866. Proc. Entomol. Soc. Phil. 6:24

The original description lists "Habitat,—New York State. Rhode Island. Several (♂ and ♀) specimens examined." A male type is at the ANSP, and to clarify application of the name we hereby designate it as LECTOTYPE for *fratercula* (Fig. 3a). The lectotype bears the labels "N. Y.", "TYPE No. 7661/Catocala/fratercula/A. R. Grote & Rob.", "C. fratercula/G + R/TYPE", "LECTOTYPE/*Catocala fratercula*/Grote & Robinson 1866/Desig. Gall & Hawks 2002." The type locality is hereby restricted to New York [USA] on the basis of the lectotype locality label. Although Forbes (1954) placed *fratercula* as a synonym of *Catocala micronympha* Guenée, Hodges et al. (1983) re-elevated *fratercula* as a northern subspecies. However, *fratercula* is indeed merely one of many infrapopulational variants found over a wide geographic range in this species, and so we return *fratercula* as a synonym of *micronympha* (REVISED SYNONYMY).

*Catocala frederici* Grote, 1872. Trans. Amer. Entomol. Soc. 4:14

The original description lists "Two specimens from Texas (Friedrich) examined in the Berlin Museum." These two female syntypes are in Drawer 157 at the Museum für Naturkunde of Humboldt University in Berlin (ZMHU), and to clarify application of the name we hereby designate the first female as LECTOTYPE for *frederici* (Fig. 3b). The lectotype bears the labels "10923", "frederici/Grote & Rob./Texas. Friedrich", "LECTOTYPE/*Catocala frederici*/Grote 1872/Desig. Gall & Hawks 2002." The type locality is Texas [USA]. We recognize *Catocala frederici* as a full species.

*Catocala guenei* Grote, 1887. Can. Entomol. 19:115.

The name *guenei* is the second published and hence unnecessary replacement name for *Catocala viduata* Guenée (1852). The first published replacement name for *viduata* is *Catocala maestosa* Hulst (1884). Since *guenei* is a replacement name, its type locality is the same as for Guenée's *viduata*, namely Georgia, [USA].

*Catocala habilis* Grote, 1872. Trans. Amer. Entomol. Soc. 4:11

The original description states "A number of coincident specimens examined from Pennsylvania." A male type is at the ANSP, and to clarify application of the name we hereby designate it as LECTOTYPE for *habilis* (Fig. 3d). The lectotype bears the labels "Penn.", "TYPE No. 7664/Catocala/habilis/A. R. Grote", "Catocala/habilis/Grote/TYPE", "LECTOTYPE/*Catocala habilis*/Grote 1872/Desig. Gall & Hawks 2002." The type



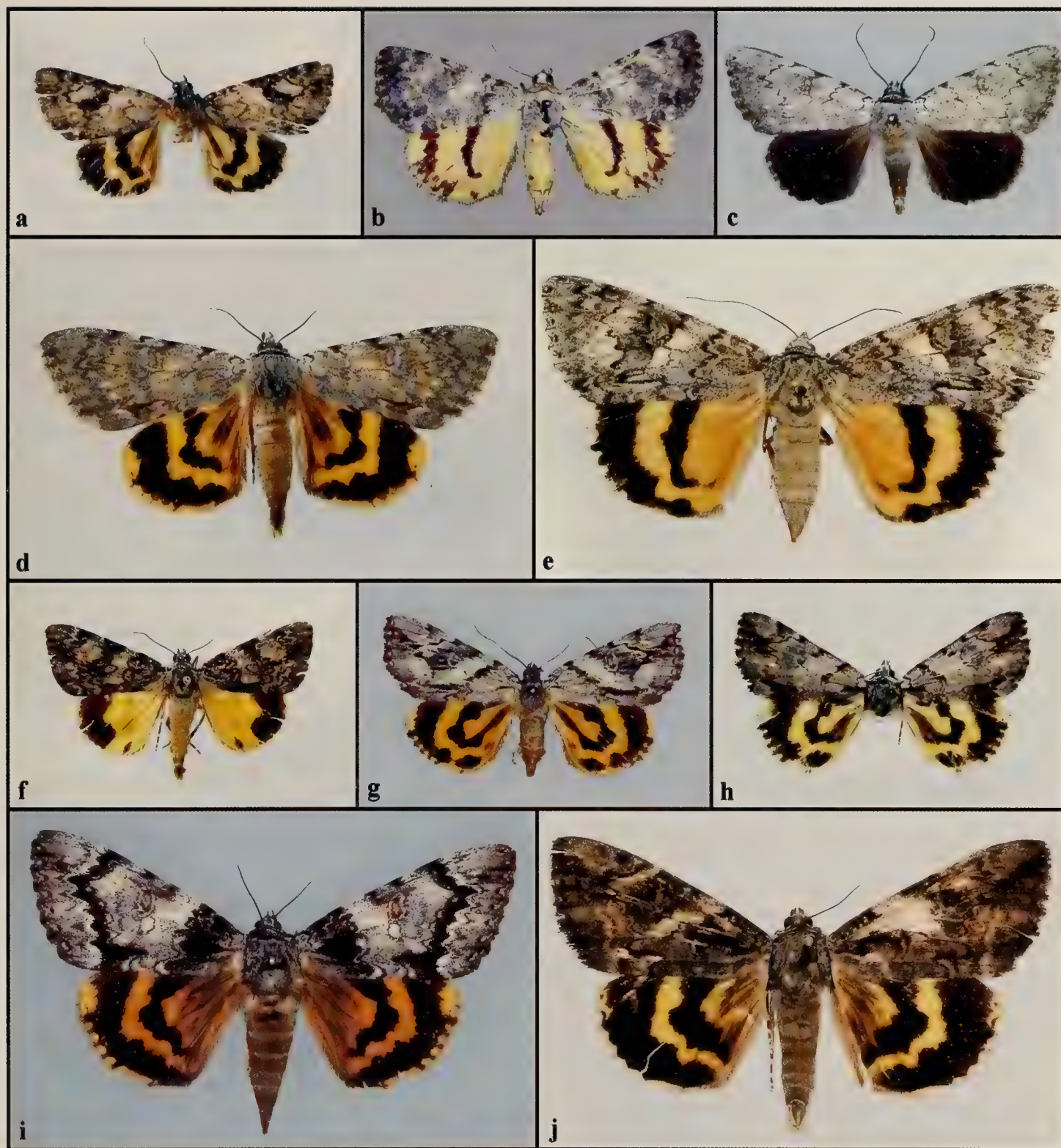


FIG. 3. Type specimens of moths in the genus *Catocala* Schrank. A. R. Grote types (authorship is Grote unless otherwise noted). **a**, lectotype, *fratercula* Grote & Robinson. **b**, lectotype, *frederici*. **c**, lectotype, *levettei*. **d**, lectotype, *habilis*. **e**, lectotype, *meskei*. **f**, lectotype, *lineella*. **g**, lectotype, *mira*. **h**, lectotype, *praeclara* Grote & Robinson. **i**, lectotype, *phalanga*. **j**, lectotype, *piatrix*. 0.9–1.0 × natural size.

locality is Pennsylvania [USA]. We recognize *Catocala habilis* as a full species.

*Catocala levettei* Grote, 1874c. Trans. Amer. Entomol. Soc. 5:95

The original description does not state the number of types. A male labelled as type by Grote is in Drawer

1 at the BMNH, bearing a red BMNH type disc. The specimen label indicates Ohio, but the original description calls for Indianapolis. Hampson (1913) and Beutenmüller (1903a) stated the type of *levettei* was at the BMNH, and we have no other reason other than this probable labeling error to believe this BMNH male is not an available syntype. To clarify application



of the name we hereby designate it as **LECTOTYPE** for *levettei* (Fig. 3c). The lectotype bears the labels "Ohio./Grote Coll./81-116.", "Ohio/81-116 [and on the reverse:] Catocala/levettei/Type Grote", "Catocala/levettei/Type. Grote", "LECTOTYPE/Catocala levettei/Grote 1874/Desig. Gall & Hawks 2002." We give precedence to Grote's original description and retain the type locality as Indianapolis, [Marion County, Indiana, USA]. The name *levettei* is a synonym of *Catocala judith* Strecker.

*Catocala lineella* Grote, 1872. Trans. Amer. Entomol. Soc. 4:18

The systematics of the 'amica complex' of small Nearctic *Catocala* species has been the recent focus of breeding and field work by D. F. Schweitzer and ourselves. We know of four species, three of which have available names, and one undescribed sibling species that lacks an available name. *Catocala jair* Strecker is the rarest, most distinctive, and most geographically restricted of the four species. The other three are widespread, with *Catocala amica* (Hübner) and *Catocala lineella* Grote being the most frequently encountered in most areas of eastern North America. *Catocala lineella* had been treated as a subspecies or synonym of *Catocala amica* during the 20th century, but it was restored to the rank of full species by Gall (1990).

The usage and applicability of *amica* and *jair* have been fixed in the literature for some time, and although the usage of *lineella* has been modestly stable, Barnes and McDunnough (1918b) were unaware of a type. The original description of *lineella* indicates "a number of coincident specimens." In Drawer 34 at the BMNH is a male with a blue-bordered Grote label. To clarify application of the name we hereby designate it as **LECTOTYPE** for *lineella* (Fig. 3f). The lectotype bears the labels "E. U. S. America/Grote Coll./81-116.", "19/6", "8.", "E. States/81-116 [and on the reverse:] Allotria/lineella/Grote", "Catocala /Schk./lineella/Grote", "LECTOTYPE/Catocala lineella/Grote 1872/Desig. Gall & Hawks 2002." Grote listed the type locality for *lineella* as "Same localities as *C. androphila*," which was "Eastern States, southward." We recognize *Catocala lineella* as a full species.

*Catocala meskei* Grote, 1873. Can. Entomol. 5:161

The original description states "Lent me by Mr. O. Meske, after whom I name the species, from near Albany, N. Y., and who writes me that it has been taken in considerable numbers by a collector in that vicinity." Although this suggests a single specimen, the number of types is not explicitly stated. To clarify application of

the name we hereby designate the female at the USNM as **LECTOTYPE** for *meskei* (Fig. 3e). The lectotype bears the labels "August/1873.", "Catocala/meskei/Grote/Type", "Type/No. 305/U.S.N.M." "Collection/O. Meske", "LECTOTYPE/Catocala meskei/Grote 1873/Desig. Gall & Hawks 2002." The type locality is Albany, [Albany County,] N[ew] Y[ork, USA]. We recognize *Catocala meskei* as a full species.

*Catocala mira* Grote, 1876a. Can. Entomol. 8:230

The original description does not state the number of types. In Drawer 29 at the BMNH is a female with a red-bordered Grote type label, bearing a red BMNH type disc. To clarify application of the name we hereby designate it as **LECTOTYPE** for *mira* (Fig. 3g). The lectotype bears the labels "388", "U. S. America/Grote Coll./81-116.", "United States/81-116 [and on the reverse:] Catocala/mira/Type Grote", "C. mira/Grote/Type", "LECTOTYPE/Catocala mira/Grote 1876/Desig. Gall & Hawks 2002." The type locality is hereby restricted to the USA on the basis of the lectotype locality label. We recognize *Catocala mira* as a full species.

*Catocala moderna* Grote, 1900. Can. Entomol. 32:191

The original description states "Accompanying the fresh type [of *moderna*] are examples of *C. viduata*, Guen." The male holotype by monotypy is in Drawer 33 of Cabinet "Neu 3" at the Roemer- und Pelizaeus Museum (RUPM) in Hildesheim, Germany. The type locality is Dolores, Texas [USA]. The name *moderna* is a synonym of *Catocala maestosa* Hulst.

*Catocala phalanga* Grote, 1864a. Proc. Entomol. Soc. Phil. 3:86

The original description states "Coll. Ent. Soc. Philadelphia . . . Possibly a variety of *Catocala palaeogama*, but, as several coincident specimens have occurred, it may be distinct." There are several old, unlabeled specimens of *phalanga* at the ANSP, including one pinned in a style like that of other Grote types at ANSP. In Drawer 4 at the BMNH is a male bearing a blue-bordered Grote label. We give precedence to the BMNH male labeled by Grote, and to clarify application of the name hereby designate it as **LECTOTYPE** for *phalanga* (Fig. 3i). The lectotype bears the labels "U. S. America/Grote Coll./81-116.", "var. phalanga/Grote", "United States/81-116 [and on the reverse:] "C. palaeogama/var. phalanga/Grote", "LECTOTYPE/Catocala phalanga/Grote 1864/Desig. Gall & Hawks 2002." The type locality is Middle States [USA]. The name *phalanga* is a synonym of *Catocala palaeogama* Guenée, and represents specimens with a



prominent black postmedian line and black basal patch on the forewing.

*Catocala piatrix* Grote, 1864a. Proc. Entomol. Soc. Phil. 3:88

The original description states "Coll. Ent. Soc. Philadelphia," but does not indicate the number of specimens. In Drawer 5 at the BMNH is a male bearing a blue-bordered Grote label. There are several old males at the ANSP, but none labeled by Grote. A male now at the CMNH, ex ANSP via accession 20359, is labeled as *piatrix* by Grote, and bears a machined locality label like that on other ANSP *Catocala* types. We give precedence to the CMNH male, and to clarify application of the name hereby designate it as LECTOTYPE for *piatrix* (Fig. 3j). The lectotype bears the labels "N.Y.", "Catocala/piatrix/Gr./A.R.G.", "Exch. A.N.S.P./C. M. Acc. 20359", "LECTOTYPE/Catocala piatrix/Grote 1864/Desig. Gall & Hawks 2002." The type locality is hereby restricted to N[ew] Y[ork, USA] on the basis of the lectotype locality label. We recognize *Catocala piatrix* as a full species.

*Catocala ponderosa* Grote & Robinson, 1866. Proc. Entomol. Soc. Phil. 6:23

The original description states "Habitat.—Illinois, New York, Pennsylvania. Coll. Ent. Soc. Philadelphia. Several specimens examined." Two unlabeled male *nebulosa* are at the ANSP. In Drawer 4a at the BMNH is a female bearing a blue-bordered Grote label. We give precedence to the BMNH female labeled by Grote, and to clarify application of the name hereby designate it as LECTOTYPE for *ponderosa* (Fig. 4a). The lectotype bears the labels "6", "U.S. America/Grote Coll./81-116", "Catocala/ponderosa/G + R", "United States/81-116 [and on the reverse:] Catocala/ponderosa/Gr. + Rob.", "LECTOTYPE/Catocala ponderosa/Grote & Robinson 1866/Desig. Gall & Hawks 2002." The type locality can not be restricted further. The name *ponderosa* is a synonym of *Catocala nebulosa*.

*Catocala praeclara* Grote & Robinson, 1866. Proc. Entomol. Soc. Phil. 6:25

The original description states "Our Collection and that of Ent. Soc. Phil., numerous (♂ and ♀) coincident specimens examined." At the CMNH is a female *praeclara*, ex ANSP via accession 20359, bearing a handwritten label in pencil stating "presumed TYPE." This penciled label is in the same handwriting as penciled "TYPE" designations on other types at the ANSP. To clarify application of the name we hereby designate this CMNH female as LECTOTYPE for *praeclara* (Fig. 3h). In addition to the above label, the lectotype bears the la-

bels "N. Y.", "praeclara", "Exch. A.N.S.P./C. M. Acc. 20359", "LECTOTYPE/Catocala praeclara/Grote & Robinson 1866/Desig. Gall & Hawks 2002." The type locality is New York [USA]. We recognize *Catocala praeclara* as a full species.

*Catocala residua* Grote, 1874a. Proc. Boston Soc. Nat. Hist. 16:242

The original description lists "Hab. New York (in Coll. Buf. Soc. Nat. Sciences); Canada (J. Petit). Three coincident specimens examined," and Smith (1893:354) states "The type of *residua* is in the American Museum of Natural History from the Angus Collection." This female is at the AMNH, and to clarify application of the name we hereby designate it as LECTOTYPE for *residua* (Fig. 4b). The lectotype bears the labels "No. 486/Coll. J. Angus/West Farms, New York City.", "Type/No./A.M.N.H.", "C. residua/Grote/var.", "LECTOTYPE/Catocala residua/Grote 1874/Desig. Gall & Hawks 2002." Because Angus often affixed a printed West Farms label as a "return address," rather than as a locality label, we cannot be certain whether the AMNH female is from New York or Canada, and so we leave the type locality as originally published. We recognize *Catocala residua* as a full species.

*Catocala relecta* Grote, 1872. Trans. Amer. Entomol. Soc. 4:4

The original description states "A few specimens examined from the Middle States." A male type is at the ANSP, and to clarify application of the name we hereby designate it as LECTOTYPE for *relecta* (Fig. 4c). The lectotype bears the labels "7", "TYPE No. 7660/Catocala/relecta/A. R. Grote", "LECTOTYPE/Catocala relecta/Grote 1872/Desig. Gall & Hawks 2002." The type locality is Middle States [USA]. We recognize *Catocala relecta* as a full species.

*Catocala robinsoni* Grote, 1872. Trans. Amer. Entomol. Soc. 4:20

The original description states "After writing so far my kind friend, Mr. Charles A. Blake, sends me specimens of two black winged species from Pennsylvania . . . ♂♀ . . ." There are several old *robinsoni* at the ANSP, pinned in a style like other Grote types at ANSP. A male and female in Drawer 3 at the BMNH bear conflicting locality and date labels, and no type designations. To clarify application of the name, we hereby designate a male from the ANSP collection as LECTOTYPE for *robinsoni* (Fig. 4d). The lectotype bears the labels "Penn.", "LECTOTYPE/Catocala robinsoni/Grote 1872/Desig. Gall & Hawks 2002." The type locality is Pennsylvania [USA]. We recognize *Catocala robinsoni* as a full species.



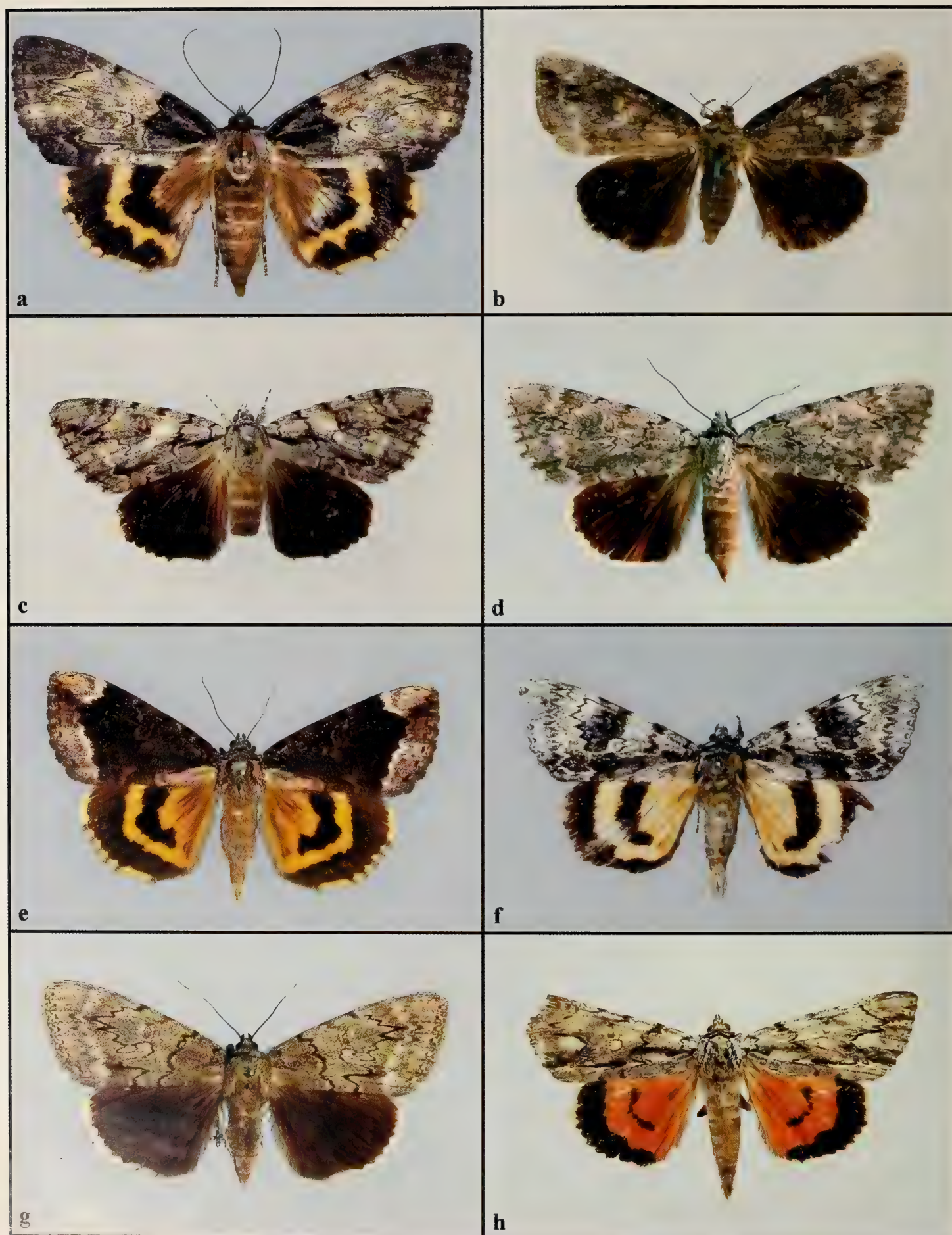


FIG. 4. Type specimens of moths in the genus *Catocala* Schrank. A. R. Grote types (authorship is Grote unless otherwise noted). **a**, lectotype, *ponderosa* Grote & Robinson. **b**, lectotype, *residua*. **c**, lectotype, *resecta*. **d**, lectotype, *robinsoni*. **e**, lectotype, *scintillans* Grote & Robinson. **f**, lectotype, *semirelicta*. **g**, lectotype, *simulatilis*. **h**, lectotype, *sinuosa*. 0.9–1.0 × natural size.



*Catocala scintillans* Grote & Robinson, 1866. Proc. Entomol. Soc. Phil. 6:28

The original description states "Pennsylvania. Coll. Ent. Soc. Phil." In Drawer 3a at the BMNH is a female bearing a blue-bordered Grote label, and labeled as type by Butler. This female bears a conflicting and probably erroneous locality label indicating Ohio as the locality. At the ANSP are two old specimens of *scintillans*, one female from Ohio ex Strecker collection and one unlabeled male pinned in a style matching other Grote types at the ANSP. We place greater confidence in the blue-bordered label on the BMNH female, and hereby designate it as LECTOTYPE for *scintillans* (Fig. 4e). The lectotype bears the labels "Ohio", "Ohio/Grote Coll./81-116.", "Ohio/81-116 [and on the reverse:] Catocala/scintillans/Type Grote & Robinson", "Catocala/scintillans/G + R.", "LECTOTYPE/Catocala scintillans/Grote & Robinson 1866/Desig. Gall & Hawks 2002." We retain the originally published Pennsylvania [USA] as the type locality. The name *scintillans* is a synonym of *Catocala innubens* Guenée, and represents specimens with a crisply delimited, wide white distal area on the forewing.

*Catocala semirelictica* Grote, 1874b. Sixth Ann. Rep. Peabody Acad. Sci., p. 35

The original description does not state the number of types. In Drawer 17a at the BMNH is a male bearing a blue-bordered Grote label and a red-bordered type label, and a red BMNH type disc. To clarify application of the name we hereby designate it as LECTOTYPE for *semirelictica* (Fig. 4f). The lectotype bears the labels "U. S. America/Grote Coll./81-116.", "This spec. was exhibited in the/Can. Coll. at the Centennial 1876/and has lost its color from exposure", "United States/81-116 [and on the reverse:] Catocala/semirelictica/Type Grote", "Catocala/semirelictica/Grote", "Catocala/semirelictica/Type Grote", "LECTOTYPE/Catocala semirelictica/Grote 1874/Desig. Gall & Hawks 2002." The type locality is Grimsby, Ontario [Canada]. We recognize *Catocala semirelictica* as a full species.

*Catocala simulatilis* Grote, 1874c. Trans. Amer. Entomol. Soc. 5:94

The original description states "Ohio, Dr. Hodge, two specimens." In Drawer 2 at the BMNH is a female, bearing a red BMNH type disc, and labeled as type by Grote. Although this specimen claims to be from New York, this is probably a mislabeling, and we place greater confidence in Grote's published statement. To clarify application of the name we hereby designate this specimen as LECTOTYPE for *simu-*

*latis* (Fig. 4g). The lectotype bears the labels "N. Y./Grote Coll./New York", "New York/81-116 [and on the reverse:] Catocala/simulatilis/Grote Type", "C. simulatilis/Type Grote", "LECTOTYPE/Catocala simulatilis/Grote 1874/Desig. Gall & Hawks 2002." We retain the originally published Ohio [USA] as the type locality. The name *simulatilis* is a synonym of *Catocala obscura* Strecker.

*Catocala sinuosa* Grote, 1879. Can. Entomol. 11:15

The original description states "Two specimens. Florida, Mr. Albert Koebele." In Drawer 26a at the BMNH is a male, bearing a blue-bordered Grote label and a red-bordered type label, and a red BMNH type disc. To clarify application of the name we hereby designate it as LECTOTYPE for *sinuosa* (Fig. 4h). The lectotype bears the labels "U.S. America/Grote Coll./81-116.", "No. 3", "United States/81-116 [and on the reverse:] Catocala/sinuosa/Type Grote", "Catocala/sinuosa/Grote", "Catocala/sinuosa/Type/Grote", "LECTOTYPE/Catocala sinuosa/Grote 1879/Desig. Gall & Hawks 2002." The type locality is Florida [USA]. We recognize *sinuosa* as a subspecies of *Catocala coccinata* Grote with lighter forewings and a greatly reduced, sometimes obsolete hindwing median band. Specimens from peninsular Florida are referable to *sinuosa*, whereas nominate *coccinata* occurs elsewhere in North America. We have, however, seen occasional specimens similar to *sinuosa* from the Gulf Coast outside of Florida.

*Catocala snowiana* Grote, 1876b. Checklist Noct. Amer., p.41

The original description does not state the number of types. A female at the AMNH is labeled by Grote as type of "snowi," and to clarify application of the name we hereby designate it as LECTOTYPE for *snowiana* (Fig. 5a). The lectotype bears the labels "390", "No. 11876/Collection/Hy. Edwards.", "Type/No./A.M.N.H.", "Catocala/snowi/Type", "LECTOTYPE/Catocala snowiana/Grote 1876/Desig. Gall & Hawks 2002." The type locality is Kansas [USA]. The lectotype of *snowiana* is a specimen of *Catocala palaeogama* Guenée. Thus, *snowiana* is hereby transferred from the synonymy of *Catocala neogama* J. E. Smith to that of *palaeogama* (REVISED SYNONYMY).

*Catocala sordida* Grote, 1877. Can. Entomol. 9:170

The original description states "In Mrs. Bridgham's collection is (or rather, was) a specimen labeled *similis* by Mr. Edwards, which belonged to what I consider as a variety of *gracilis*, having the primaries mixed bluish gray, and the basal dash of *gracilis* is wanting. This last



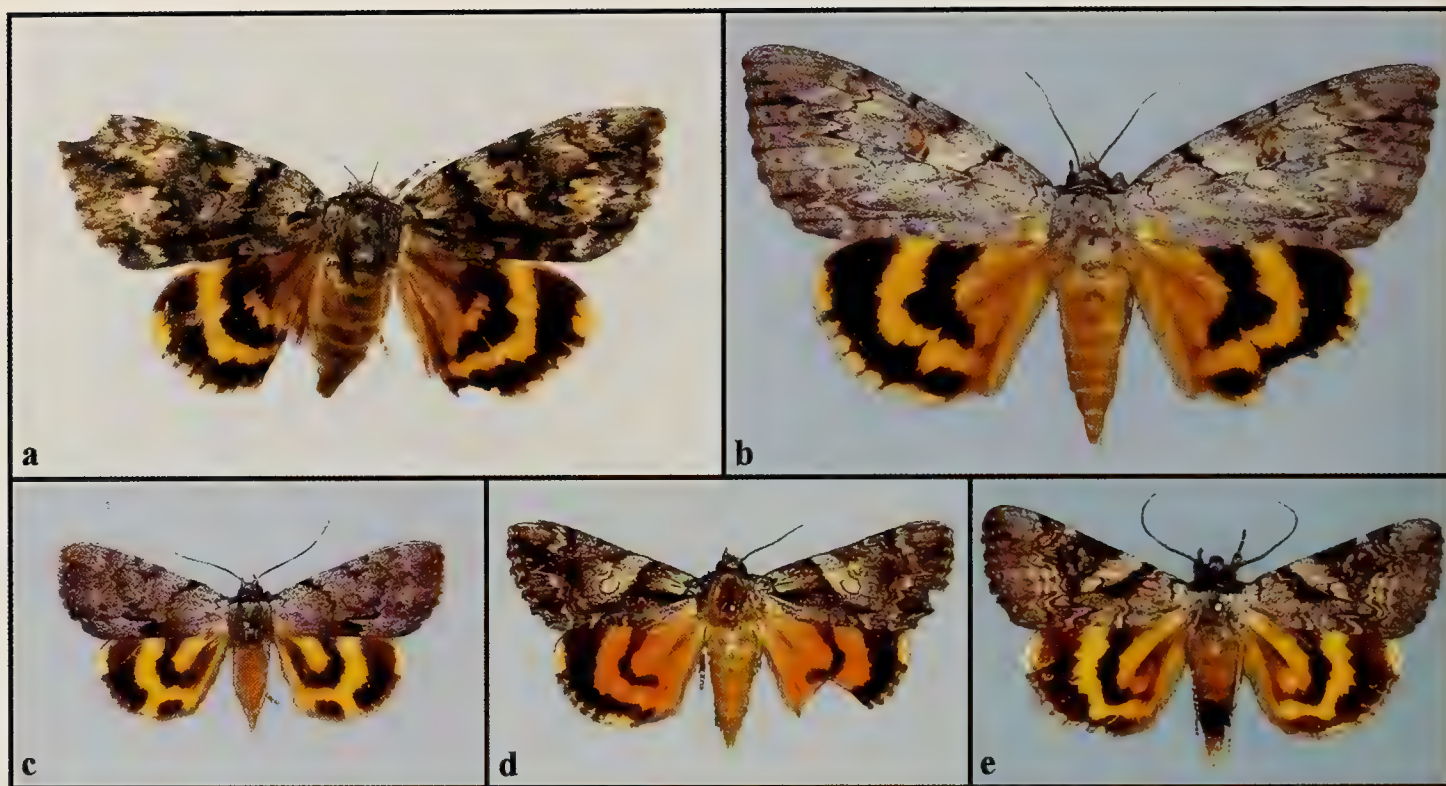


FIG. 5. Type specimens of moths in the genus *Catocala* Schrank. A. R. Grote types (authorship is Grote unless otherwise noted). **a**, lectotype, *snowiana*. **b**, lectotype, *subnata*. **c**, lectotype, *sordida*. **d**, lectotype, *verrilliana*. **e**, lectotype, *westcottii*. 0.9–1.0 × natural size.

seems the only important character . . . This dark form (which seems also a little shorter winged) has been taken with the type by myself near Buffalo, and by Dr. Bailey near Albany. I have seen it also from Pennsylvania . . . This mixed dark blue-gray form, with distinct black lines and without the small basal streak of *gracilis*, I propose to designate by the name *sordida* . . . A female ex Bailey collection is in Drawer 23 at the BMNH, bearing a red-bordered type label, and a red BMNH type disc. As Grote correctly noted, there is no specimen of *sordida* labeled *similis* by Edwards in the Bridgman material now at the YPM, although there is a series of 12 *gracilis*. To clarify application of the name we designate the female at the BMNH as LECTOTYPE for *sordida* (Fig. 5c). The lectotype bears the labels “Grote Coll./81-116.”, “Centre, N.Y./July 12, 1877./Dr. J. S. Bailey./Collector”, “New York/81-116 [and on reverse:] C. *gracilis*/var. *sordida*/Type Grote”, “var. *sordida*/Type Grote”, “LECTOTYPE/*Catocala sordida*/Grote 1877/Desig. Gall & Hawks 2002.” The type locality is hereby restricted to Centre, [Albany County], N[ew] Y[ork, USA] on the basis of the lectotype locality label. We recognize *Catocala sordida* as a full species.

*Catocala subnata* Grote, 1864b. Proc. Entomol. Soc. Phil. 3: 133

The original description states “Hab. Maryland. (Coll. Ent. Soc. Phil.).” There are two old unlabeled males at the ANSP. A female *subnata* is in Drawer 5 at the BMNH, bearing a red BMNH type disc and labeled as type by Butler, but with a conflicting locality label “Kansas.” This female also bears a red-bordered label without type attribution, stating only “*Catocala subnata*,” and not in Grote’s handwriting. In the same series in Drawer 5 is a male *subnata* bearing a blue-bordered Grote label.

The text of the original description of *subnata* was based on the male, and the accompanying illustration in Fig. 4 of Plate 5 is definitely a male, lacking the basal dashes and darker scaling on the forewing typical of female *subnata*. The BMNH specimen purporting to be a type is a strongly marked female, and it clearly does not match the illustration in Fig. 4 of Plate 5. We are willing to accept Hampson’s (1913:39) statement that the BMNH holds a type of *subnata*, but challenge his assertion that this is the female with two contradictory labels, as the male therein bearing Grote’s blue-bordered label is a far more plausible candidate. We suggest an erroneous association occurred, and we hereby designate the male in Drawer 5 as LECTOTYPE for *subnata* (Fig. 5b). The lectotype bears the labels “U. S. America/Grote Coll./81-116.”, “United States/81-116 [and on the reverse:] *Catocala/sub-*



nata/Grote", "Catocala/subnata/Grote", "LECTOTYPE/*Catocala sordida*/Grote 1877/Desig. Gall & Hawks 2002." The type locality is Maryland [USA]. We recognize *Catocala subnata* as a full species.

*Catocala verrilliana* Grote, 1875a. Can. Entomol. 7:185

The original description does not state the number of types. In Drawer 27 at the BMNH is a male labeled as type by Grote, bearing a red BMNH type disc. To clarify application of the name we hereby designate it as LECTOTYPE for *verrilliana* (Fig. 5d). The lectotype bears the labels "499", "U. S. America/Grote Coll./81-116", "United States/81-116 [and on the reverse:] *Catocala/verrilliana*/Type Grote", "*Catocala/verrilliana*/Type/Grote", "LECTOTYPE/*Catocala verrilliana*/Grote 1875/Desig. Gall & Hawks 2002." The type locality is Bosque Co[unty], Texas [USA]. We recognize *Catocala verrilliana* as a full species.

*Catocala westcottii* Grote, 1878. Can. Entomol. 10:195

The original description discusses two specimens: "I have the male from Illinois, Mr. Bean, number 577; the female from Wisconsin, Mr. O. S. Westcott, for whom I name the species." The male is in Drawer 25 at the BMNH, bearing a red BMNH type disc, and to clarify application of the name we hereby designate it as LECTOTYPE for *westcottii* (Fig. 5e). The lectotype bears the labels "577", "U. S. America/Grote Coll./81-116.", "United States/81-116 [and on reverse:] *Catocala/westcottii*/Type Grote", "*Catocala/westcottii*/Grote/Type", "LECTOTYPE/*Catocala westcottii*/Grote 1878/Desig. Gall & Hawks 2002." The type locality is hereby restricted to Illinois [USA] on the basis of the lectotype labels. The name *westcottii* is a synonym of *Catocala amestris* Strecker.

#### Infrasubspecific Names

*Catocala habilis* var. "**basalis**" Grote, 1876a. Can. Entomol. 8:230

The original description states "Specimens received from Mr. Robert Bunker, taken about Rochester, N. Y." There is a female in Drawer 5 at the BMNH, labeled as type by Butler and bearing a red BMNH type disc, with a locality label "Oneida Co./Aug. 1876/Dr. J. S. Bailey./Collector." Oneida County is about 80 miles from Rochester proper, and is not inconsistent with the statement "taken about Rochester." We leave the type locality as Rochester, N[ew] Y[ork] USA, as originally published. The name "basalis" is a synonym of *Catocala habilis* Grote, and represents the typical female of this species.

*Catocala cerogama* var. "**bunkeri**" Grote, 1876a. Can. Entomol. 8:230

The original description does not state the number of types. In Drawer 22 at the BMNH is a female bearing a red-bordered Grote label that lacks the word type, but with a type designation by Butler. The type locality is New York [USA]. The name "bunkeri" is a synonym of *Catocala cerogama* Guenée, and represents specimens with the hindwing "yellow basal shade entirely lost."

*Catocala innubens* var. "**flavidalis**" Grote, 1874c. Trans. Amer. Entomol. Soc. 5:95

The original description states "I have received from Prof. S. A. Forbes, Normal, Illinois, a specimen with the number '2' attached to it." In Drawer 3a at the BMNH is a male labeled by Grote as "var flavidalis/Grote," and bearing a handwritten label "2." Neither Beutenmüller (1903a) nor Hampson (1913) list the type of "flavidalis" as being among the Nearctic *Catocala* at the BMNH, but Beutenmüller (1903b) indicates the type is there, and from the label data we are confident the BMNH male is the holotype by monotypy. The type locality is not stated in the original description, but is presumably [Illinois, USA]. The name "flavidalis" is a synonym of *Catocala innubens* Guenée, and represents an aberration with yellowish hindwing bands.

*Catocala concumbens* ab. "**hilli**" Grote, 1883b. Papilio 3:43

The original description states "This very singular aberration has been taken by Mr. W. W. Hill at Center, N. Y." This female, the holotype by monotypy, is at the New York State Museum (NYSM) in Albany. The type locality is Center, [Albany County,] N[ew] Y[ork] USA. The name "hilli" is a synonym of *Catocala concumbens* Walker, and represents an aberration with yellowish hindwing bands.

#### ACHILLE GUENÉE

As was the case with many lepidopteran groups, comparative study of the Nearctic species of *Catocala* did not really commence until the 1850's, with the publication of A. Guenée's (1852) *Species General* and F. Walker's ([1858]) *List of the specimens of lepidopterous insects in the collection of the British Museum*. Guenée described 17 Nearctic *Catocala* in 1852, and he and Walker are the most important European workers to have published on the Nearctic species. Guenée obtained *Catocala* for his own collection from several North American sources, and had



the opportunity to study Boisduval's collection and that of the BMNH, which included Doubleday and Abbot material. Most of Guenée's original descriptions cite specimens, but he also described two Nearctic *Catocala* from unpublished paintings by John Abbot.

Identifying many of Guenée's noctuid species was an odyssey for Nearctic workers. Although Grote traveled to France to visit Guenée and examine his type material, Grote was unable to resolve noctuids that Guenée had based on Abbot paintings. In a biography of Guenée, he summarized his opinion as follows (Grote 1881b): "[Guenée] drew up descriptions of several species [of North American noctuids] from drawings by Abbot, and none of these have been satisfactorily identified and probably cannot be." J. B. Smith toured many of the European collections for his noctuid catalogue, and stated therein (1893:9) "I did succeed in getting at most of the species marked 'M.N.,' in the Species General. I was in hopes of being able to get track of the Abbot drawings, from which Guenée described a number of species; but I did not succeed in this;" he also indicated that while at the BMNH his "time was limited, I did not study *Acronycta*, which Dr. Riley had already studied on a prior occasion, nor *Catocala*, which Messrs. Grote and Henry Edwards had compared."

The first person to claim to know the identity of the Guenée *Catocala* names *connubialis*, *messalina* and *micronympha* was G. D. Hulst (1884). Hulst was unfamiliar with these taxa just a few years earlier (Hulst 1880), and apparently based his 1884 opinions not on comparisons of specimens but on a letter he received in the intervening years from A. G. Butler of the BMNH. Hulst's prior nomenclatural actions in the genus had already come under blistering attack by Grote (1881c), and Hulst's rather sudden "understanding" of the Guenée names simply became additional fodder for the long-running feud between these two workers (e.g., Grote 1891, 1892; Hulst 1881, 1892). Nevertheless, over the ensuing several decades, Hulst's concepts of *connubialis*, *messalina*, and *micronympha* became fixed in the Nearctic literature.

In his diagnosis of *messalina*, Hulst (1884:34) stated that "Mr. Charles Oberthur, of Rennes, France, to whom Guenée's types came, informs me that when they came into his possession, all were found to be destroyed beyond the possibility of recovery by the larvae of *Anthrenus* [dermestids]. So no identification can be made of any of Guenée's American species described from imagines, from the types themselves." Although Hulst's statement may be true for *messalina*, since we have not located any types, it is demonstrably false for Guenée's other *Catocala*, as W. Barnes obtained both

these and Guenée's other North American moth types from C. Hofer in 1927 prior to the transfer of the Oberthur collection to the BMNH. The Guenée *Catocala* types are at the USNM, bearing Guenée, Oberthur, and Barnes collection/accession labels, as well as Guenée's distinctive handwritten type labels in French.

Because Guenée described a number of lepidopteran species based on paintings by John Abbot, we wish to elaborate here on the pioneering work of this man, one of the most productive early naturalists in North America during the late 18th and early 19th centuries. John Abbot reared, collected, and painted native birds, insects, and plants of the southeastern United States, and was one of the primary sources of specimen material for customers in Europe and North America at the time. He executed thousands of paintings, the vast majority of which was never published. A meticulous and revealing book on Abbot's life and accomplishments was published recently by Gilbert (1998).

Only four of Abbot's paintings of Nearctic *Catocala* were published, in *The Natural History of the Rarer Lepidopterous Insects of Georgia* (Smith [& Abbot] 1797). In that tome, four new species of *Catocala* were described from the four Abbot paintings, these being *amasia* (J. E. Smith), *consors* (J. E. Smith), *neogama*, and *vidua* (J. E. Smith). The identity of the latter three names as separate species was settled quickly by the 19th century Nearctic *Catocala* workers, whereas the applicability of the name *amasia* was not completely resolved until well into the 20th century (see Gall 1992, and our treatment below of *connubialis* Guenée; the name *amasia* J. E. Smith was recently suppressed [ICZN 1994]).

Abbot painted many other species of Nearctic *Catocala*, and these paintings survive today in several locations. The two most notable compilations are the bound volumes in the Entomology Library of the BMNH (ex Francillon collection) and the Houghton Library at Harvard University (ex Oemler collection), both of which we have examined. Among the 17 quarto volumes at the BMNH are 14 plates illustrating 18 individual *Catocala*, and at Houghton are 16 plates illustrating 21 individual *Catocala* (see Table 2). Together, the BMNH and Houghton plates depict at least 18 different species. Ten plates are common to both BMNH and Houghton, showing the same species on the same backgrounds, and these likely represent standard illustrations that Abbot's clients could request (see Gilbert 1998).

Perhaps not surprisingly, given his keen eye and long-term residency in Georgia, Abbot knew of and painted several rare and/or local *Catocala* species from





FIG. 6. Type specimens of moths in the genus *Catocala* Schrank. A. Guenée types. **a**, lectotype, *andromedae*. **b**, lectotype, *androphila*. **c**, neotype, *connubialis*. **d**, lectotype, *cerogama*. **e**, lectotype, *desperata*. **f**, lectotype, *melanympha*. **g**, neotype, *micronympha*. **h**, holotype, *polygama*. **i**, lectotype, *palaeogama*. **j**, lectotype, *parta*. 0.9–1.0 × natural size.

the southeastern United States that were not “discovered” and described until late in the 20th century. For example, one of the plates present at both BMNH and Houghton clearly shows *Catocala grisatra* Brower (undescribed until 1936) at the top and *Catocala similis* at the bottom. Among the non-corresponding plates, one at Houghton depicts *Catocala louiseae* Bauer (unde-

scribed until 1965), and another at Houghton appears to depict the as yet undescribed species in the *Catocala amica* complex. At this juncture, we believe none of the 19th and early 20th century Nearctic *Catocala* workers studied Abbot’s unpublished paintings; species such as *grisatra* and *louiseae* are, in our opinion, far too distinctive to have escaped being named,



TABLE 2. The identity of Nearctic *Catocala* Schrank species figured in unpublished paintings by John Abbot, in the bound volumes housed at the Houghton Library (Harvard University, Cambridge, Massachusetts) and the Entomology Library at the Natural History Museum (London, England). For plates with two listed names, the first appears above the second on the plate.

Source	Taxon
Houghton Library (Oemler)	
pl. 123	<i>epione</i> (Drury)
pl. 124	<i>ilia</i> (Cramer)
pl. 125	<i>ultronia</i> (Hübner)
pl. 126	<i>consors</i> J. E. Smith, <i>muliercula</i> Guenée
pl. 127	<i>louiseae</i> Bauer
pl. 128	<i>lineella</i> ? Grote, <i>jair</i> ? Strecker
pl. 142	<i>sappho</i> Strecker, <i>maestosa</i> Hulst
pl. 143	<i>andromedae</i> Guenée
pl. 144	<i>amatrix</i> (Hübner)
pl. 145	<i>carissima</i> Hulst
pl. 146	<i>coccinata</i> Grote
pl. 147	<i>nebulosa</i> W. H. Edwards
pl. 148	<i>consors</i> J. E. Smith, <i>muliercula</i> Guenée
pl. 149	<i>grisatra</i> Brower, <i>similis</i> W. H. Edwards
pl. 150	<i>micronympha</i> Guenée
pl. 151	<i>amica</i> (Hübner), <i>jair</i> ? Strecker
Natural History Museum (Francillon)	
vol. 8, pl. +52	<i>carissima</i> Hulst
vol. 8, pl. 264	<i>amatrix</i> (Hübner)
vol. 8, pl. 265	<i>coccinata</i> Grote
vol. 8, pl. 266	<i>maestosa</i> Hulst
vol. 8, pl. 267	<i>nebulosa</i> W. H. Edwards
vol. 8, pl. 270	<i>amica</i> (Hübner)
vol. 8, pl. 271	<i>micronympha</i> Guenée
vol. 8, pl. 273	<i>andromedae</i> Guenée
vol. 17, pl. 29	<i>carissima</i> Hulst
vol. 17, pl. 30	<i>sappho</i> Strecker, <i>maestosa</i> Hulst
vol. 17, pl. 89	<i>ilia</i> (Cramer), <i>ilia</i> (Cramer)
vol. 17, pl. 126	<i>amica</i> (Hübner), <i>amica</i> (Hübner)
vol. 17, pl. 140	<i>grisatra</i> Brower, <i>similis</i> W. H. Edwards
vol. 17, pl. 280	<i>consors</i> J. E. Smith, <i>muliercula</i> Guenée
vol. "Tring", pl. 23	<i>amatrix</i> (Hübner)
vol. "Tring", pl. 24	<i>coccinata</i> Grote

had the paintings been seen. One complicating aspect of the bound Francillon and Oemler volumes is that the plates are labeled haphazardly. For example, at the BMNH are plates bearing the labels *vidua* (Plate 30), *amasia* (Plate 126), *consors* (Plate 140) and *neogama* (Plate 280), that is, the four J. E. Smith names of 1797. However, these plate names do not in any way match Smith's published usages. Instead, Plate 30 depicts *sappho* Strecker, Plate 126 depicts *amica*, Plate 140 depicts *grisatra* and *similis* and Plate 280 depicts *consors* and *muliercula* Guenée. In addition, plates often bear confusing subsequent annotations. For example, at Houghton, "C. *marmorata*?" appears on Plate 123 next to a painting of *Catocala ilia* (Cramer), and

"grynea? Cr." appears on Plate 127 next to a painting of *Catocala louiseae*.

There are two Nearctic *Catocala* names whose descriptions were made from reference to unpublished Abbot paintings. Both names were authored by Guenée (1852), these being *Hypogramma andromedae* and *Catocala connubialis*. Hulst (1884) first placed the name *connubialis* into the synonymy of Nearctic *Catocala* under his new species *sancta* Hulst, and Barnes and McDunnough (1918b) later introduced *andromedae* as the senior synonym of *tristis* Edwards, based on information from Hampson. Guenée's original description of *andromedae* is distinctive, and Hampson's association of this name with the previously published name *tristis* has been universally accepted. We have located unpublished Abbot plates matching the description of *andromedae*. In contrast, Guenée's original description of *connubialis* could apply to infrapopulational morphs of at least two *Catocala* species, and Hulst's association of this name with the previously published *amasia* and *cordelia* Hy. Edwards met with immediate resistance. Fortunately, Hulst's concept of *connubialis* is readily established from his type of *sancta*. However, we have not located an Abbot painting that matches Hulst's concept. We discuss these situations below.

We note here that the Entomology Library at the BMNH contains a bound volume, in excess of 450 pages and handwritten by Guenée in French, that contains extensive notes by him on the synonymy of holarctic Lepidoptera (Guenée [ca. 1857]). It also contains descriptions with manuscript names for non-European species that were never published, including *Catocala*. We were unable to glean any additional data about Guenée's published Nearctic *Catocala* names from this volume, but we recommend that lepidopteran systematists routinely consult this work when studying Guenée types, as it clearly holds significant information that complements the *Species General*.

Available Names

*Catocala andromedae* Guenée, 1852. Hist. Nat. Spec. Gen. Lepid. 7:36

Guenée described *Hypogramma andromedae* from a painting by John Abbot. The name *andromedae* was not included in the major works on Nearctic *Catocala* during the 19th century, probably because the species was originally described in another genus. The combination *Catocala andromedae* appears to have been used first in Barnes and McDunnough's (1917) checklist, and the following year in their *Catocala* mono-



graph, where they stated (1918b:36) “This species has been generally known as *tristis* Edwards but Sir Geo. Hampson has recently called our attention to the fact that Guenée’s description of *andromedae* (a name heretofore unplaced) fits this species very well; we concur with him in using Guenée’s name, which has priority.” We agree with this placement, and further note that the larval illustration of *andromedae* by Guenée (1852, fig. 11, Plate 2) is a *Catocala* and clearly matches larvae in the small group of Nearctic Ericaceae-feeding species, to which *tristis* belongs.

We have recently examined the compilations of Abbot’s unpublished works at the BMNH and the Houghton Library at Harvard University. Paintings that are readily identifiable as *tristis* appear in both compilations. To clarify application of the name we hereby designate the specimen figured (and now presumed lost) on Plate 273 in bound Abbot Volume 8 at the BMNH as LECTOTYPE for *andromedae* (Fig. 6a). The accompanying text reads “No 273. Noctua. Numeria. Caterpillar feeds on Oaks, bred 10th June, frequents Hammock, Rare, called in Savannah, small black underwing.” The foodplant association is erroneous, as are a number of Abbot’s. Guenée’s original description states “Amerique Septentrionale,” and on the basis of the text for Plate 273 and the published accounts of Abbot’s activities (see Gilbert 1998) we hereby restrict the type locality to Georgia, USA. We recognize *Catocala andromedae* as a full species.

*Catocala androphila* Guenée, 1852. Hist. Nat. Spec. Gen. Lepid. 7:106

The original description states “Amerique Septentrionale. Coll. Gn.” Three Guenée males labeled as *androphila* are at the USNM. Two are *Catocala amica*, and one is *Catocala lineella*. Guenée’s large label in French is affixed to an *amica*, and indicates that the first two specimens in his series (both *amica*) are “ordinaire” whereas the third in the series (the *lineella*) is “var A. Gn. p. 107” (this confirms that Grote 1872:18 had correctly surmised that his new species *lineella* was Guenée’s var A). The label also says “Amer. Boreale. 1845,” and then “I have not seen since then a large enough number, all alike, sender also [unintelligible] Baltimore, but I have not seen the female.” To clarify application of the name we hereby designate the male bearing Guenée’s large label in French as LECTOTYPE for *androphila* (Fig. 6b). In addition to Guenée’s label, the lectotype bears the labels “Ex Musaeo/Ach. Guenée”, “Oberthur/Collection”, “Barnes/Collection”, “LECTOTYPE/*Catocala androphila*/Guenée 1852/Desig. Gall & Hawks

2002.” The type locality is hereby amended to Amer[ique] Boreale on the basis of the lectotype locality label. Barnes and McDunnough (1918b:45) pointed out that Guenée intended the name *androphila* to replace the name *amica* (Hübner), which Guenée mistakenly believed was preoccupied by the Palearctic species *Hadena amica* Treitschke (1825). The name *androphila* is a synonym of and unnecessary replacement name for *Catocala amica* (Hübner).

*Catocala cara* Guenée, 1852. Hist. Nat. Spec. Gen. Lepid. 7:87

The original description states “Coll. Gn. Un ♂.” A male bearing a large Guenée label in French stating “No. 1” is at the USNM. This specimen also bears another label “Type/see label” by F. H. Benjamin, and we consider it to be the holotype by monotypy. The type locality is the vicinity of Baltimore [Maryland, USA]. We recognize *Catocala cara* as a full species.

*Catocala cerogama* Guenée, 1852. Hist. Nat. Spec. Gen. Lepid. 7:96

The original description states “Coll. Feisth. Gn. et M. N.” A male and female are at the USNM, both bearing Guenée labels in French. The two labels were once part of a single label, and indicate: “[on the male] 1. Poor ♂ from the collection of Feisthamel. / [on the female] 2. Good ♀ vicinity of Baltimore, purchased M. Becker in 1852.” To clarify application of the name we hereby designate the female as LECTOTYPE for *cerogama* (Fig. 6d). In addition to Guenée’s label, the lectotype bears the labels “Ex Musaeo/Ach. Guenée”, “Oberthur/Collection”, “Barnes/Collection”, “LECTOTYPE/*Catocala cerogama*/Guenée 1852/Desig. Gall & Hawks 2002.” The type locality is hereby restricted to the vicinity of Baltimore [Maryland, USA] on the basis of the lectotype locality label. We recognize *Catocala cerogama* as a full species.

*Catocala connubialis* Guenée, 1852. Hist. Nat. Spec. Gen. Lepid. 7:105

Guenée described *Catocala connubialis* from a painting by John Abbot. Eventually, nearly a century later, as a result of life history and related studies, the names *amasia* and *connubialis* were recognized to be infrasubspecific morphs (along with *cordelia*, *sancta* and *virens* French) of one of the most variable Nearctic *Catocala* species. Since 1938, the name *connubialis* has been applied to the species because *amasia* (published by J. E. Smith in 1797) was considered preoccupied by *Catocala amasia* Esper (1787), an unrelated Palearctic species thought to have been published in



1796. However, Heppner (1981) showed that Esper's work dates from 1804, not 1796. The applicable history was reviewed by Gall (1992) in a petition accepted by the ICZN (1994) to conserve the name *connubialis* Guenée and suppress the name *amasia* J. E. Smith.

As noted above, Hulst was the first Nearctic *Catocala* worker to claim to understand the identity of *connubialis*. He first mentioned the name (1884:34) in his account of *Catocala messalina*: "Connubialis heretofore not identified, was described from a colored drawing of Abbott which is now, I understand, in the British Museum." Later in the same paper, Hulst (1884:38) described *Catocala sancta* as new, placing *connubialis* as its synonym. The description of *sancta* follows: "These last two species [*amasia* and *similis*] have been much confused. Abbott's upper figure, from which Smith says his description was made, is undoubtedly the insect afterwards named *cordelia* by Hy. Edwards. Guenée describes the lower figure of Abbott as *amasia*; but Abbott's description of the upper figure, holds good against that of Guenée. Mr. Grote identified the more southern form as *amasia*, and thus it is generally labelled in collections. Mr. A. G. Butler [of the BMNH] writes me, this latter is *connubialis*, Guen.: but the description does not fit, and it was described from a drawing, and so the name does not in any case hold." At the end of the same paper, Hulst (1884:56) commented further on the Butler letter, stating "Page 38, line 15, after 'writes me' insert 'his opinion is.' I do not understand that he has ultimate evidence. At any rate the description being based on a picture, can not stand."

Hulst (1892:74) later elaborated his position: "Prof. French says 'var. *Virens* is not a variety of *Cordelia*, Hy. Edw., but of *Amasia*; and *Cordelia* is not the one figured by Dr. Strecker, pl. 9, f. 12.' But *cordelia*, Hy. Edw., is a synonym of *amasia*, Ab. & Sm., and Dr. Strecker's figure is not *amasia*, Ab. & Sm. The error comes from the fact that Abbot & Smith figured two species as male and female of *amasia*, the description being of the upper one only. The insect represented by the lower figure of Abbot & Smith was distributed by Mr. Grote, and figured by Dr. Strecker as *amasia*. Of course the name attaches to the figure described, as afterwards Guenée located it, calling the lower figure *connubialis*. The lower insect I afterwards described as *sancta*, regarding Guenée's name as without authority, as the description was from a picture. Whether I was right or not I will not here say, but the insect distributed by Mr. Grote, and figured by Dr. Strecker as *amasia*, is either *connubialis*, Gn., or *sancta*, Hulst; while the *amasia* of Abbot & Smith is the *cordelia* of Hy. Edwards, as Mr. Edwards afterwards acknowledged to

me." This last sentence is Hulst's most succinct diagnosis of *connubialis*.

The two species shown on Smith and Abbot's Plate xc are indeed not conspecific, and not even that close morphologically. This was first noted by Grote and Robinson (1866), who restricted the name *amasia* to the upper illustration and applied the name *formula* to the lower illustration (*formula* was later transferred to the synonymy of *similis*). This interpretation of Plate xc was followed by all the Nearctic *Catocala* workers, and Hulst (1884:37) had already unequivocally adopted this interpretation in his synonymies for both *similis* ("pl. 90 lower figure") and *amasia* ("pl. 90, upper fig."). Hulst described *sancta* in the same 1884 paper as distinct from both *similis* and *amasia*, and his type of *sancta* is identical to Strecker's Plate 9 Fig. 12 and not in any way confusable with *similis*. Yet later, Hulst (1892:74) equally unequivocally assigned his *sancta* to the lower illustration of Plate xc. Unless one is willing to assume that by 1892 Hulst felt his *sancta* was conspecific with *similis*, for which we have no evidence whatsoever, his 1884 and 1892 synonymic treatments appear to be irreconcilable.

In his noctuid catalogue, Smith (1893:334) did not resolve this problem when he indicated: "Dr. Hulst cites this species [*connubialis*], as well as *amasia*† Grt., to *sancta*, perhaps not justly. There is really no evidence that Guenée intended the *amasia*†, and indeed, Dr. Hulst says the description does not fit. It [*connubialis*] should not therefore be cited as a synonym to *sancta*, which it must otherwise replace. Guenée's species based on Abbot's figures have been universally accepted, and if the figures are still in existence there is no reason why positive knowledge should not yet be obtainable."

Even though Guenée's concept of *connubialis* had not yet been adequately established, Smith's statement probably cemented the link between *connubialis* and *sancta*. Hulst's contemporaries could readily determine Hulst's concept of *connubialis* by reference to the type of *sancta* and Strecker's illustration on his Figure 12 on Plate 9. On the other hand, Hulst's own understanding of *connubialis* was apparently based solely on the letter sent to him by Butler, and this letter was undoubtedly not generally available to other *Catocala* workers at the time (we have been unable to locate any letters from Butler to Hulst in the archives of Rutgers College, or in the Butler correspondence at the BMNH). Moreover, Butler's concept of *connubialis*, and hence Hulst's, unquestionably stems from Walker's *List* (1858:1207–1208), in which specimen material at the BMNH is attributed to *connubialis*. Indeed, in Drawer 32a at the BMNH are two similar



males labeled as *connubialis* by Butler. These BMNH specimens match Hulst's type of *sancta* at the AMNH and Strecker's illustration, and are also consistent with Guenée's original description of *connubialis*. The undersurface of Butler's label on one of the males reads "Catocala/connubialis var./Type Walker."

We had hoped to locate an Abbot painting that matched the BMNH specimens Butler labeled as *connubialis*, but we found no matching painting at either the BMNH or at the Houghton Library, nor in the collections of Abbot *Catocala* plates at the CMNH, the ANSP, or the Atlanta History Center. Because (a) no Abbot painting unequivocally attributable to *connubialis* has been located, (b) the original description of *connubialis* is also consistent with some infrapopulational morphs of Guenée's *micronympha*, (c) no type for *micronympha* has been located, and (d) the early Nearctic *Catocala* workers had trouble differentiating the small yellow-hindwinged species, we consider it essential to fix the name *connubialis* firmly. To clarify application of the name, we hereby designate the BMNH male labeled as type of the variety by Butler as NEOTYPE for *connubialis* (Fig. 6c). The neotype bears the labels "United States/-? [and on the reverse:] Catocala/connubialis var./Type Walker", "NEOTYPE/Catocala connubialis/Guenée 1852/Desig. Gall & Hawks 2002." Guenée gives a type locality of "Amerique septentrionale," but because Abbot does not seem to have ever figured this morph, and the neotype bears no precise locality data, we leave the type locality as stated by Guenée. We recognize *Catocala connubialis* as a full species.

*Catocala desperata* Guenée, 1852. Hist. Nat. Spec. Gen. Lepid. 7:95

The original description states "Amerique Septentrionale, environs de Baltimore. Coll. Gn. Un ♂, une ♀." A Guenée male labeled "desperata/Baltimore" is at the USNM, and to clarify application of the name we hereby designate it as LECTOTYPE for *desperata* (Fig. 6e). In addition to Guenée's label, the lectotype bears the labels "Ex Musaeo/Ach. Guenée", "Oberthur/Collection", "Barnes/Collection", "LECTOTYPE/Catocala desperata/Guenée 1852/Desig. Gall & Hawks 2002." The type locality is the vicinity of Baltimore [Maryland, USA]. The name *desperata* is a synonym of *Catocala vidua* J. E. Smith.

*Catocala innubens* Guenée, 1852. Hist. Nat. Spec. Gen. Lepid. 7:98

The original description states "Amerique Septentrionale. Coll. Bd. Un ♂. Parait rare." A male labeled "innubens/Gn. 25" and "Ex Musaeo/A. Kuwert 1894"

is at the USNM (Oberthur obtained the noctuid portions of Kuwert's [1828–1894] collection, and other Guenée *Catocala* type material at the USNM bears Kuwert collection labels). We consider this USNM male to be Guenée's holotype by monotypy, since the handwriting on the first label matches that on other USNM Guenée types. The type locality is "Amerique Septentrionale." We recognize *Catocala innubens* as a full species.

*Catocala insolabilis* Guenée, 1852. Hist. Nat. Spec. Gen. Lepid. 7:94

The original description states "Coll. Gn. Une ♀ . . . [Variety] A . . . Coll. Gn. Un ♂," indicating a female holotype by monotypy. There are four male *insolabilis* at the USNM that are apparently from Guenée's collection, although only two bear his accession labels. We have not located a female, and Guenée appears to have accurately sexed all his other Nearctic *Catocala* types. The first Guenée male in the USNM series is worn, and the second male is in good condition. The worn male bears a large Guenée label in French that states: "Baltimore ♀ M. Becker. The ♂ that I have described is [unintelligible] poor [unintelligible] into a collection. I doubt [unintelligible] variety, in all, as I have supposed, [unintelligible] the No. 1 ♂ which arrives since is quite similar to the female." We believe the worn male is the one on which Guenée's variety A was based. In the original description, Guenée was uncertain whether variety A represented the typical male of the species, but his specimen label seems to corroborate a correct association of the sexes. Because the original description is diagnostic, and there has been no confusion regarding the applicability of the name, we choose not to take any formal action. The type locality is hereby restricted to Baltimore [Maryland, USA] on the basis of Guenée's label. We recognize *Catocala insolabilis* as a full species.

*Catocala lacrymosa* Guenée, 1852. Hist. Nat. Spec. Gen. Lepid. 7:93

The original description states "Coll. Gn. Un beau ♂." This Guenée male, the holotype by monotypy, is at the USNM. Its large Guenée label in French offers no substantive additional information beyond that provided in the original description. The type locality is "Amerique Septentrionale." We recognize *Catocala lacrymosa* as a full species.

*Catocala melanympha* Guenée, 1852. Hist. Nat. Spec. Gen. Lepid. 7:98

The original description states "Canada. Coll. Gn. Parait rare." Three Guenée males labeled *melanympha*



are at the USNM, and to clarify application of the name we hereby designate the male bearing Guenée's large label in French as LECTOTYPE for *melanympha* (Fig. 6f). In addition to Guenée's label, which indicates the specimen was sent by Feisthamel, the lectotype bears the labels "Ex Musaeo/Ach. Guenée", "Oberthur/Collection", "Barnes/Collection", "LECTOTYPE/*Catocala melanympha*/Guenée 1852/Desig. Gall & Hawks 2002." The type locality is Canada. The name *melanympha* is a synonym of *Catocala antinympha* (Hübner).

*Catocala messalina* Guenée, 1852. Hist. Nat. Spec. Gen. Lepid. 7:107

The original description states "Amerique Septentrionale. Coll. Bdv. Un ♂." Grote (1872:19) translated Guenée's original description of *messalina*, and stated "Not identified by me. . . . This species should be recognisable from the continuous hind border of the secondaries, an exceptional character of this group." Hulst (1884) embellished Grote's translation but correctly identified the species, listing *jocasta* Strecker and *belfragiana* Harvey as synonyms. We have been unable to locate a type of *messalina* at the USNM or at the BMNH. However, the original description of this unique species is diagnostic, and there has been no confusion regarding the applicability of the name since Hulst's diagnosis, so we choose not to take any formal action. The type locality is "Amerique Septentrionale." We recognize *Catocala messalina* as a full species.

*Catocala micronympha* Guenée, 1852. Hist. Nat. Spec. Gen. Lepid. 7:102

As with *connubialis* and *messalina*, Hulst (1884:34) was the first Nearctic worker to claim to know the identity of *micronympha*. However, unlike *connubialis* and *messalina*, Hulst offered no justification whatever for his placement of *micronympha*, stating only "An extraordinarily variable species. Atarah is slightly lighter than type form." Although Grote (1891:281) properly protested that "without the slightest reason, Mr. Hulst quotes *fratercula* [the previous oldest name] as the species intended by Guenée as *micronympha*," the name *micronympha* was used in the catalogue by Smith (1893) and as the species name by subsequent authors.

The original description of *micronympha* states "Amerique Septentrionale. Un ♂." There are no Guenée specimens labeled by Guenée as *micronympha* among the type material at either the USNM or the BMNH. However, there are two worn male Guenée specimens of *micronympha* at the USNM that are labeled by Guenée as *amasia*, and the large label in French on one male indicates it was used

for his 1852 description of *amasia*. The confusion among the 19th century *Catocala* workers regarding *amasia* sensu Guenée (which does not correspond well to Abbot's painting of *amasia* J. E. Smith) is now much more readily understandable, given the label data affiliated with the two USNM *micronympha*. These two USNM *micronympha* represent an intrapopulational variant lighter than "hero" Hulst that occurs in *micronympha* from the southern United States viz., forewings of a dull cream color, with variable brown shading in the postmedial area and the outer margin.

Because (a) we have not located the *micronympha* holotype, (b) Hulst's placement of *micronympha* was made without substantiating published evidence, (c) the original description of *micronympha* is consistent with some intrapopulational morphs of *connubialis*, and (d) the early Nearctic *Catocala* workers had trouble differentiating the small yellow-hindwinged species, we consider it essential to fix the name *micronympha* firmly. Accordingly, we hereby designate a male from the AMNH as NEOTYPE for *micronympha* (Fig. 6g). The neotype bears the labels "USA: Georgia: Liberty Co./St. Catherines Island/May 1991/Rozen, Quinter & Sharkov", "NEOTYPE/*Catocala micronympha*/Guenée 1852/Desig. Gall & Hawks 2002." The type locality is hereby amended to S[ain]t Catherines Island, Liberty Co[unty], Georgia, USA on the basis of the neotype label. We recognize *Catocala micronympha* as a full species.

*Catocala muliercula* Guenée, 1852. Hist. Nat. Spec. Gen. Lepid. 7:97

The original description states "Amerique Septentrionale. Coll. Bdv. Un ♂." We have not been able to locate Guenée's holotype at either the USNM or the BMNH. However, the original description is diagnostic, and we further note that the larval illustration of *muliercula* by Guenée (1852, fig. 15, Plate 2) matches the distinctive larvae in the small Nearctic group of Myricaceae-feeding species, to which *muliercula* belongs. Since there is no indication in the early Nearctic *Catocala* literature of confusion as to the applicability of this name, we choose not to take any formal action. The type locality is "Amerique Septentrionale." We recognize *Catocala muliercula* as a full species.

*Catocala palaeogama* Guenée, 1852. Hist. Nat. Spec. Gen. Lepid. 7:97

The original description states "Amerique Septentrionale. Coll. Bdv. et Feisth." and then "A . . . Memes localities. Coll. Gn. Un ♂." (Guenée's variety A is *phalanga* Grote). There are two male Guenée *palaeogama* at the USNM. One male bears a large Guenée label in



French that discusses four specimens, and indicates “♂ vicinity of Baltimore purchased Becker;” the other male is labeled simply “*palaeogama*.” To clarify application of the name we hereby designate the male bearing Guenée’s large label as LECTOTYPE for *palaeogama* (Fig. 6i). In addition to Guenée’s label, the lectotype bears the labels “Ex Musaeo/Ach. Guenée”, “Oberthur/Collection”, “Barnes/Collection”, “LECTOTYPE/*Catocala palaeogama*/Guenée/Desig. Gall & Hawks 2002.” The type locality is hereby restricted to the vicinity of Baltimore [Maryland, USA] on the basis of the lectotype locality label. We recognize *Catocala palaeogama* as a full species.

*Catocala parta* Guenée, 1852. Hist. Nat. Spec. Gen. Lepid. 7:84

The original description states “Amerique Septentrionale, Canada. Coll. Gn. Trois exemplaires.” Three male and one female Guenée *parta* are at the USNM. Two males and one female bear sections of what had previously been a single large Guenée label in French, and the fourth male only bears a label stating “Canada.” The three Guenée label segments together indicate “Amerique du Nord. 1. male purchased from Becker? / 2. ♀ id. id. in 1851. Baltimore. / 3. ♂ poor from coll. Feisthamel.” To clarify application of the name we hereby designate the female as LECTOTYPE for *parta* (Fig. 6j). In addition to Guenée’s label, the lectotype bears the labels “Ex Musaeo/Ach. Guenée”, “Oberthur/Collection”, “Barnes/Collection”, “LECTOTYPE/*Catocala parta*/Guenée 1852/Desig. Gall & Hawks 2002.” The type locality is hereby restricted to Baltimore [Maryland, USA] on the basis of the lectotype locality label. We recognize *Catocala parta* as a full species.

*Catocala polygama* Guenée, 1852. Hist. Nat. Spec. Gen. Lepid. 7:105

The original description states “Amerique Septentrionale, Canada. Coll. Bdv. Un ♂.” We have not been able to locate Guenée’s type at either the USNM or the BMNH. Although *polygama* has been tabulated as a junior synonym of *Catocala grynea* (Cramer 1780) since the early part of the 20th century, reanalysis of the original description and especially of Guenée’s accompanying illustration on Fig. 2 of Plate 16 (reproduced in our Fig. 6h) reveals that *polygama* is in fact an unused senior synonym of *Catocala alabamae* Grote (1876a). A petition is currently pending at the ICZN (Gall 2002) to suppress the name *polygama* and conserve the name *alabamae*. We review the history and evidence here.

Following Guenée’s description, Grote (1872:15–16)

applied *polygama* to “[specimens from] (Canada to Virginia) which differ in appearance among themselves but which I cannot separate . . . I think we have to do with a single variable species.” Grote distributed specimens determined by him as *polygama* to many workers, and thus the name *polygama* sensu Grote became widely used for a common and well-collected *Catocala* species from northeastern North America—viz, what lepidopterists currently call *blandula* Hulst. For example, Saunders (1876:72) described *Catocala crataegi* from Ontario, Canada as a new species, and provided detailed larval and adult descriptions of both it and *polygama*, showing significant points of distinction; Saunders’ description of the larva of *polygama* is a precise match for the larva of *blandula*, and matches the larva of no other *Catocala* species from eastern Canada.

In the first of his two treatises on *Catocala*, Hulst (1880:6–7) placed Grote’s *alabamae* as a variety of *grynea*; and *pretiosa*, *crataegi* and *mira* Grote (1876a) as “sub-varieties” of *polygama*. In his second treatise, Hulst (1884:35–39) returned *crataegi* and *mira* to full species status, and noted, correctly, that Grote had misidentified Guenée’s *polygama*. To resolve this, Hulst placed *polygama* sensu Guenée as a synonym of *grynea*, and proposed the new name *blandula* for the previously misidentified species *polygama* sensu Grote. Hulst (1884:35) did not unequivocally resolve *polygama* sensu Guenée, as indicated by his use of “*C. polygama*, Guen. Noct. 7, 105, pl. 16, f.2, (?)” in his synonymy for *grynea*. Hulst (1884:36) elaborated: “The description of *polygama*, Guen., seems to fit this species [*grynea*]; the figure [given by Guenée], which is poor, seems more like var. *alabamae*; neither description nor figure approach the insect identified as *polygama* by Grote.” Under his treatment of *blandula*, Hulst (1884:39) added: “With regard to *polygama*, Guen., a glance at his figure Noct. 3, pl. 16, f. 2, will convince any one that this species [*blandula*] could not have been intended. The primaries and secondaries are entirely different. The description accords with *grynea*, and the figure fits it as well as any species known to me.”

Smith (1893) followed Hulst in placing both *polygama* sensu Guenée and *alabamae* as synonyms of *grynea*, and *polygama* sensu Grote as a synonym of *blandula*. Dyar (1903) apparently skirted the issue of Grote’s misidentification, and listed *polygama* as a full species with *blandula* as its synonym, and treated *alabamae* as a full species. Hampson (1913) placed *polygama* as a synonym of *grynea*, both *blandula* and *mira* as synonyms of *crataegi*, and treated *alabamae* as a full species. In their monograph of the Nearctic *Catocala*, Barnes & McDunnough (1918b:40) treated



*polygama* as a synonym of *grynea*, and both *blandula* and *alabamae* as full species, indicating: "It should be borne in mind that the '*polygama* Guenée,' referred to by Lintner, Saunders, and others of the older authors is not the true species but probably what we have designated as *blandula* Hulst . . . Guenée's figure of *polygama* is very poor but we do not see to what other species [i.e., *grynea*] it can be referred; it is certainly not *blandula*." McDunnough's (1938) checklist followed Barnes and McDunnough's taxonomy, and *polygama* has not been used as a species name since that time. Forbes (1954:336) placed *polygama* back under *alabamae* "(probably *polygama* Guenée)" as had Hulst, but Nearctic works after 1954 have listed *polygama* under the synonymy of *grynea* (e.g., Tietz 1971, Hodges et al. 1983, Covell 1984, Poole 1989) as had Barnes & McDunnough. Note that some early 20th century authors, notably R. Rowley, used *polygama* in error as the species name for *mira* (e.g., Rowley & Berry 1910, cf. comments by Barnes & McDunnough 1918a:172–173; in his account of *mira*, Forbes 1954:335 indicated "*polygama* of American authors in large part, not Guenée").

Unquestionably, Grote's initial misidentification of *polygama*, Hulst's (1884) placement of both *polygama* and *alabamae* as synonyms of *grynea*, and the relative scarcity of specimen material for this group of closely related yellow-hindwinged species were all responsible for the volatile position of *polygama* in the 19th and early 20th century Nearctic literature. Some adults of this species group can be difficult to determine, but as a result of life history work during the first half of the 20th century, and, especially, more recent studies by ourselves and colleagues (e.g., H. D. Baggett, W. A. Miller, D. F. Schweitzer, J. R. Slotten) it is now firmly established that *alabamae*, *blandula*, *crataegi*, *grynea*, *mira*, and *pretiosa* are all distinct species. The adults breed true, with multiple broods of each species having been reared ex ovo; many specimens of each species also have been reared ex wild larvae and the larvae of most are separable.

Guenée's (1852) Fig. 2 on Plate 16 of *polygama* is clearly not *blandula*, and just as clearly is neither *crataegi*, *mira*, nor *pretiosa*. However, *polygama* is also not *grynea*. Instead, Guenée's figure of *polygama* is an acceptable albeit stylized rendering of *alabamae*, as suggested both by Forbes (1954) and originally by Hulst (1884:36) when he named *blandula* and corrected Grote's misidentification. Guenée's figure of *polygama* agrees with Grote's description of and type of *alabamae* at the BMNH (accounting for sexual differences: the *alabamae* type is a female, whereas the *polygama* figure is a male), as well as to other speci-

mens of *alabamae* from along the Gulf Coast of the southern United States, especially Florida. Specific points of distinction include: (1) the forewing ground color of Guenée's figure of *polygama* is warm light gray with brown shading, like *alabamae*, rather than deep cool greenish gray as in *grynea*; (2) the basal portion of the forewing postmedial line and anal dash of *polygama* and *alabamae* are not profusely marked with rich, chocolate brown as in *grynea*; (3) the forewing antemedial and basal lines of *polygama* are present and distinct, as in *alabamae*, rather than wanting as in *grynea*; (4) the hindwing medial band of *polygama* and *alabamae* is thinner than in *grynea*, and not heavily suffused with dark scaling along the inner margin as in *grynea*; (5) the black hindwing margin is not as wide in *polygama* and *alabamae* as in *grynea*; (6) and the black hindwing margin is sharply discontinuous (separating into a distinct basal dot) in *polygama*, as in *alabamae*, rather than continuous as is typical in *grynea*.

The recently described *Catocala charlottae* Brou (1988) is the remaining taxon to which the name *polygama* could potentially apply. Brou's original description (1988:116, Figs. 1–4) distinguished *charlottae* in detail from *alabamae*, which is the only other similar species occurring with *charlottae* at its Louisiana type locality: *charlottae* differs from *polygama* on points 1 and 4–6 above in the same manner as *grynea* does from *polygama*. Moreover, the dark brown around the forewing anal dash is even more extensive still in *charlottae* than in *grynea*, normally continuing into the anal margin. Thus, *polygama* does not refer to *charlottae*.

In summary, since McDunnough (1938), the name *polygama* Guenée (1852) has been erroneously treated in the Nearctic *Catocala* literature as a junior synonym of *grynea* (Cramer 1780), rather than as a senior synonym of *alabamae* Grote (1875b). Until the ICZN issues a ruling on Case 3210, we maintain existing usage, retaining *polygama* under the synonymy of *grynea*.

*Catocala uxor* Guenée, 1852. Hist. Nat. Spec. Gen. Lepid. 7:92

The original description states "Amerique Septentrionale. Coll. Bdv. Un ♀." We have not located Guenée's type, but there is no indication in the early Nearctic *Catocala* literature of confusion as to the applicability of this name, and so we choose not to take any formal action. The type locality remains "Amerique Septentrionale." The name *uxor* is a synonym of *Catocala ilia* (Cramer), and is preoccupied in the genus by *uxor* Hübner (1788), a synonym of the Palearctic species *Catocala nymphagoga* Esper (1787).



*Catocala viduata* Guenée, 1852. Hist. Nat. Spec. Gen. Lepid. 7:400

Guenée offered the name *viduata* in his Errata section (p. 400) as a nominal modification of J. E. Smith's name *vidua*, a species which Guenée had misdiagnosed earlier in his text (pp. 94–95). Hulst (1884) rectified this by proposing the replacement name *maestosa* Hulst for *viduata* (see discussion in Barnes & McDunnough 1918b:14 and Forbes 1954:325). The type locality of *viduata* is Georgia, [USA].

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EARLY STAGES OF THE ENTOMOPHAGOUS METALMARK BUTTERFLY *Alesa amesis*  
(RIODINIDAE: EURYBIINI)

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**ABSTRACT.** The immature stages of *Alesa amesis* are described in detail for the first time, and then compared to those of its sister genus, *Eurybia*.

**Additional key words:** *Eurybia*, morphology, myrmecophily, caterpillar calls.

The riodinid butterfly *Alesa amesis* (Cramer, 1777) is a widespread and often locally common member of the tribe Eurybiini with a geographic range that includes Brazil, the Guyanas, Venezuela, Colombia, Ecuador, and Peru. Recently we showed that *A. amesis* has an obligate association with *Camponotus femoratus* (Fabricius, 1804) ants, and that the entomophagous caterpillars possess morphological and behavioral adaptations for feeding on Homoptera prey. These biological aspects are summarized briefly as follows. At one site in Amazonian Ecuador we found that female *A. amesis* oviposited only in the presence of *C. femoratus* ants tending aggregations of several genera of Membracidae or Ateionidae (Homoptera) that fed on six families of plants. Oviposition by *A. amesis* occurred either adjacent to aggregations of Homoptera, or directly on an individual nymph. Available evidence suggests that *A. amesis* caterpillars feed entirely on Homoptera nymphs, and that compared to other herbivorous relatives, there has been an evolution of leg-length to accommodate their entomophagous diet. Greater comparative, behavioral, morphometric and analytical details are provided in DeVries and Penz (2000).

Given that there is little detailed information on early stages of most species of Eurybiini, and on *Alesa* in particular, here we present a detailed description of *Alesa amesis* early stages and compare them to species of their sister genus, *Eurybia* (Harvey 1987, Hanner 1998).

MATERIALS AND METHODS

Field work was conducted at the La Selva Lodge, Garza Cocha, Sucumbios Province, eastern Ecuador in the upper Amazon Basin, 75 km E.S.E. of Coca (0°29'50.3"S; 76°22'28.9"W). A detailed site description is provided in DeVries and Walla (2001).

Early stage material of *A. amesis* was field-col-

lected (caterpillars were first placed in Quinter's solution, see protocol in DeVries 1997), then stored in 70% alcohol, and later examined using light microscopy. Except for the second instar, we examined all *A. amesis* early stages. Descriptions of caterpillar morphology follow the terminology of Peterson (1962), Cottrell (1984) and Stehr (1987). Preserved material of four *Eurybia* species was compared to first and fifth instar caterpillars, and pupae of *A. amesis*. This material included: fifth instar caterpillars of *A. amesis*, *Eurybia patrona* Weymer, 1874, *E. elvina* Stichel, 1910, *E. nr. nicaeus* (Fabricius, 1775) and *E. lycisca* (Westwood, 1851), and pupae of *E. lycisca*. Comparative differences and the sources of information are presented in Table 1, and Figs. 5–17. Comparative voucher material of *Alesa* and *Eurybia* are in the Museo Nacional de Ecuador and the collection of DeVries.

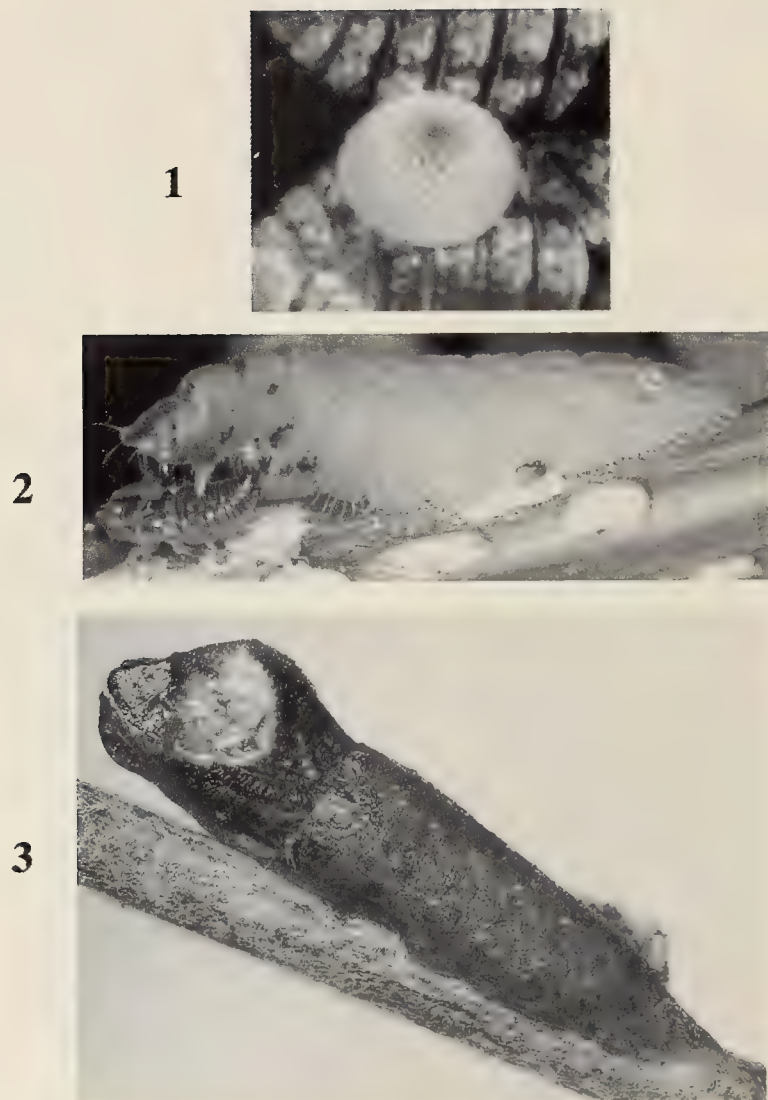
RESULTS

**Egg.** (Fig. 1) ( $n = 2$ ) Measurements: 0.83 mm wide, 0.4 mm tall. White upon being laid, turning pale green within 24 hours; base broad, tapering gently towards apex; chorion heavily adorned with rounded sculpturing that is interconnected with numerous small tubercles. Egg bears little resemblance to lozenge-shaped eggs of the sister genus *Eurybia*, but it is reminiscent of the more distantly related *Synargis* (see illustrations in DeVries 1997).

**First instar.** (Fig. 4) ( $n = 2$ ) Head pale yellow-brown with short white plumose setae on anterior portions of epicranium and frons. Body white with short, white, finely barbed setae arising from brown pinnacula; dorsal pores on T1 and A1–A8; lateral body wall extended, flange-like, contacting substrate and concealing ventral side of body. Prothoracic shield pale yellow-brown, somewhat produced anteriorly and partially covering head; anterior margin of prothoracic shield with white, barbed, forward-projecting setae. Segments T1–T3 with distinct, pale brown dorsolateral crescent-shaped marks; thoracic legs white and distinctly elongate. Prolegs white. Anal plate pale brown,

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FIGS. 1–3. *Alesa amesis* early stages in nature. **1**, Egg deposited directly on the abdomen of a membracid nymph. The overall form differs dramatically from the egg of *Eurybia* (illustrated in DeVries 1997:5). **2**, Fifth instar caterpillar using thoracic legs to grasp its membracid prey. Note shortening of body segments to expose thoracic legs. **3**, Pupa. Head oriented to the left.

narrower than remaining body segments. No evidence for tentacle nectary organs or call production found in this instar.

**Second instar.** No specimens of this instar were found.

**Third instar.** ( $n = 3$ ) Similar to fifth instar, and possessing bulb-shaped cuticular spinules covering body. As is general myrmecophilous riodinids (summarized in DeVries 1997), all third and subsequent instar caterpillars possessed a pair of tentacle nectary organs (hereafter TNOs) on segment A–8 (Figs. 2, 5, 6, 8). As in other riodinid species the TNOs of *A. amesis* produced secretions only when solicited by attending ants (DeVries & Penz 2000). The ability to produce calls was also functional in this and all subsequent instars.

**Fourth instar.** ( $n = 6$ ) Except for being smaller, indistinguishable from fifth instar. Premolt duration from fourth to fifth instar 36 to 48 h.

**Fifth instar.** (Figs. 2, 5–11) ( $n = 9$ ) **Head:** black,

anterior portion of epicranium and frons with minute tubercles and long simple setae; short simple setae distributed along entire surface of head; labrum narrow, exposing base of mandibles. **Body:** uniformly green except for light brown prothoracic shield and openings of tentacle nectary organs on A8 (some fifth instars turned brown a few days after molting, and lost all traces of green). Lateral body wall extended, flange-like and with plumose setae, contacting substrate from A2–A9 and concealing prolegs and ventral side of body (Fig. 2); ventrolateral segmental areas reduced in T1–T3 and A1, thoracic legs visible in lateral view (Fig. 2, see also DeVries & Penz 2000). **Cuticle:** covered with short spines set on broad, sclerotized bases armored with 4–8 short points (most commonly with 6 points). **Prothoracic shield:** produced anteriorly and covering head; in dorsal view, anterior margin of prothoracic shield with a distinct medial excavation and 3 pairs of long plumose setae. **Thoracic legs:** white,



TABLE 1. Comparative morphology of the early stages of *Alesa amesis* and *Eurybia*. All comparisons were done directly from preserved material unless indicated otherwise. Supplemental sources and notes are as follows: <sup>1</sup> Horvitz et al. (1987); <sup>2</sup> Malicky (1970) discusses thickened integument in larval Lycaenidae; <sup>3</sup> mandible examined in detail only in *Eurybia lycisca*; <sup>4</sup> DeVries (pers. obs); <sup>5</sup> DeVries and Penz (2000). Letters in first column correspond to details in Figs. 4–17, except for “body integument” (c), and “plantae” (m).

First Instar—Fig. 4	<i>Alesa amesis</i>	<i>Eurybia elvina</i> <sup>1</sup>
a. Prothoracic shield in dorsal view	longer and wider than head slightly covering head	narrower and shorter than head not covering head
b. Primary setae	numerous, short, thick and finely barbed	sparse, long and thin
c. Dorsal pores	present on prothorax and A1–A8	absent
d. TNOs	absent	present
Fifth Instar—Figs. 5–17	<i>Alesa amesis</i>	<i>Eurybia patrona</i> , <i>E. elvina</i> , <i>E. lycisca</i> , <i>E. nicea</i>
a. Body shape in lateral view	distinctly humped at mid-length	not humped at mid-length
b. Ventrolateral areas of body segments	T1–T3 and A1 conspicuously short, exposing legs; A2–A8 elongated and hiding prolegs	largely uniform length across all body segments
c. Body integument <sup>2</sup>	thicker than <i>Eurybia</i> and most other myrmecophilous riodinids	similar in thickness to most other myrmecophilous riodinids
d. Cuticular spines	long, set on sclerotized base armored with 4–8 points (most commonly 6)	short, without sclerotized base
e. Frontal and adfrontal regions of head	densely covered with thick, nub-like setae	<i>Eurybia patrona</i> , <i>E. nicea</i> , <i>E. lycisca</i> lack these setae; <i>E. elvina</i> with some scattered, slightly thicker setae
f. Distal segment of antenna	long	short
g. Maxilla	comparatively small	comparatively large
h. Mandible	stout, with short teeth	slender, somewhat paddle-shaped, with long teeth <sup>3</sup>
i. Stemmata	comparatively large	comparatively small
j. Prothorax in dorsal view	covering head	not covering head
k. Thoracic legs <sup>5</sup>	allometrically longer than other riodinid caterpillars	not differing allometrically from other riodinid caterpillars
l. Position of spiracles on A1	centered and slightly above the spiracular line	near anterior margin and below the spiracular line
m. Plantae	comparatively broad	comparatively narrow
n. Lateroseries of crochets	crochets short and widely spaced	crochets long and densely packed
o. TNOs	externally stalked and armored	externally an un-stalked slit
p. Anal plate	small and approximately rectangular posterior margin of A8 projected to enclose anal plate	large and oval, posterior margin of A8 not projected
Pupa—Fig. 3	<i>Alesa amesis</i>	<i>Eurybia elvina</i> <sup>1</sup> , <i>E. lycisca</i>
a. Body shape	stout	slender
b. Proboscis	short	elongate, extending beyond cremaster
c. Pupation site	uncovered pupae attached to plant stems	typically concealed within sheathing stems of host plant <sup>1,4</sup>

slightly darker at tarsi. Plantae of prolegs broad. **Anal plate:** rectangular, small, not well differentiated from rest of abdomen, and enclosed by posterolateral expansions of A8.

**Pupa.** (Fig. 3) (n = 7) Light to dark brown, elongate, tallest and widest anteriorly and tapering gradually from head to cremaster. In ventral view, antennae terminate at posterior margin of A6, and proboscis terminates distally at posterior margin of T3 (for comparison, see Horvitz et al. 1987:517 fig. 4B, DeVries 1997:137 fig. 40A). In lateral view, head and anterior portion of thorax resemble a miniature monkey face. T1 yellowish brown with an excavated anterior margin

and covering head in dorsal view; thoracic spiracle red. T2–T3 with large white to green crescent mark. Pupa with skirt on A4–A10 that projects ventrally and flares over substrate; ventral side concave from T3 (approximately) to A10 to adjust for shape of pupation substrate. Silk girdle across A1; A1 and A8 conspicuously shorter than A2–A7; A9 reduced. Cremaster broad, longer than other abdominal segments, and slightly curved ventrally. Duration of pupa 15–17 days (n = 3; 2 males, 1 female). Pupation in nature occurred on small stems at base of plants associated with *Camponotus femoratus* colonies, and pupae were attended by ants.



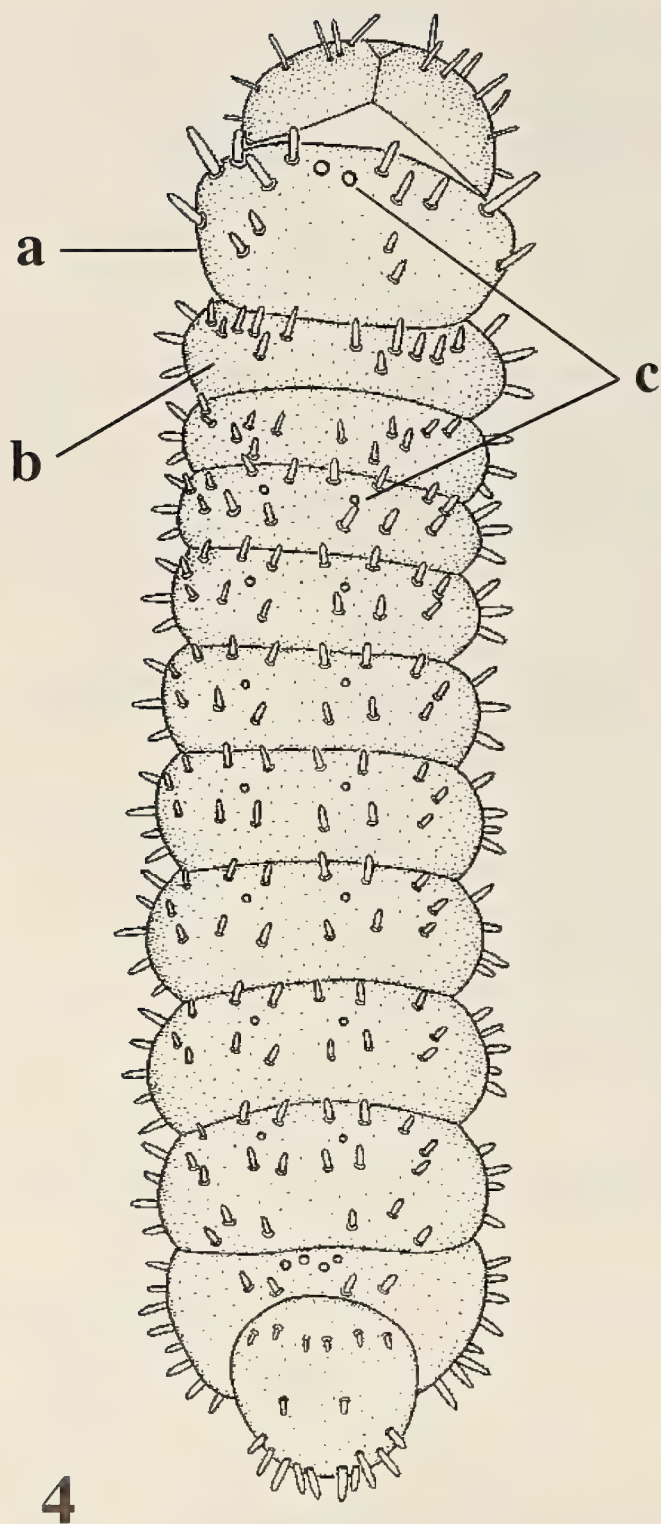


FIG. 4. First instar of *Alesa amesis*. Note size of prothoracic shield (a), primary setae (b), and dorsal pores (c).

#### DISCUSSION

Previously the only available detailed description of Eurybiini early stage morphology was that of *Eurybia elvina* by Horvitz et al. (1987). The present study shows that caterpillars and pupae of *A. amesis* may differ considerably from *Eurybia* (Table 1, Figs. 4–17). For example, although all instars of *Eurybia elvina* apparently possess TNOs (Horvitz et al. 1987)

these organs are absent in first instar *A. amesis*. Other differences among *A. amesis* and *Eurybia* caterpillars include body shape, cuticular spines, relative thoracic and abdominal leg size, crochets, stemmata, antennae, and maxilla (Figs. 5–17). Traits like elongated thoracic legs, broad proleg plantae and the ventrolateral shortening of segments T1–3 and A1 in *A. amesis* caterpillars may reflect their entomophagous habit since they potentially facilitate curling of the body during prey capture and feeding. Other characteristics of *A. amesis* caterpillars may be due to their forming symbioses with ants (e.g., long cuticular spines in sclerotized, armored bases; thickened body integument; armored, stalked TNOs). However, the evolutionary basis and adaptive nature of such traits remain uncertain.

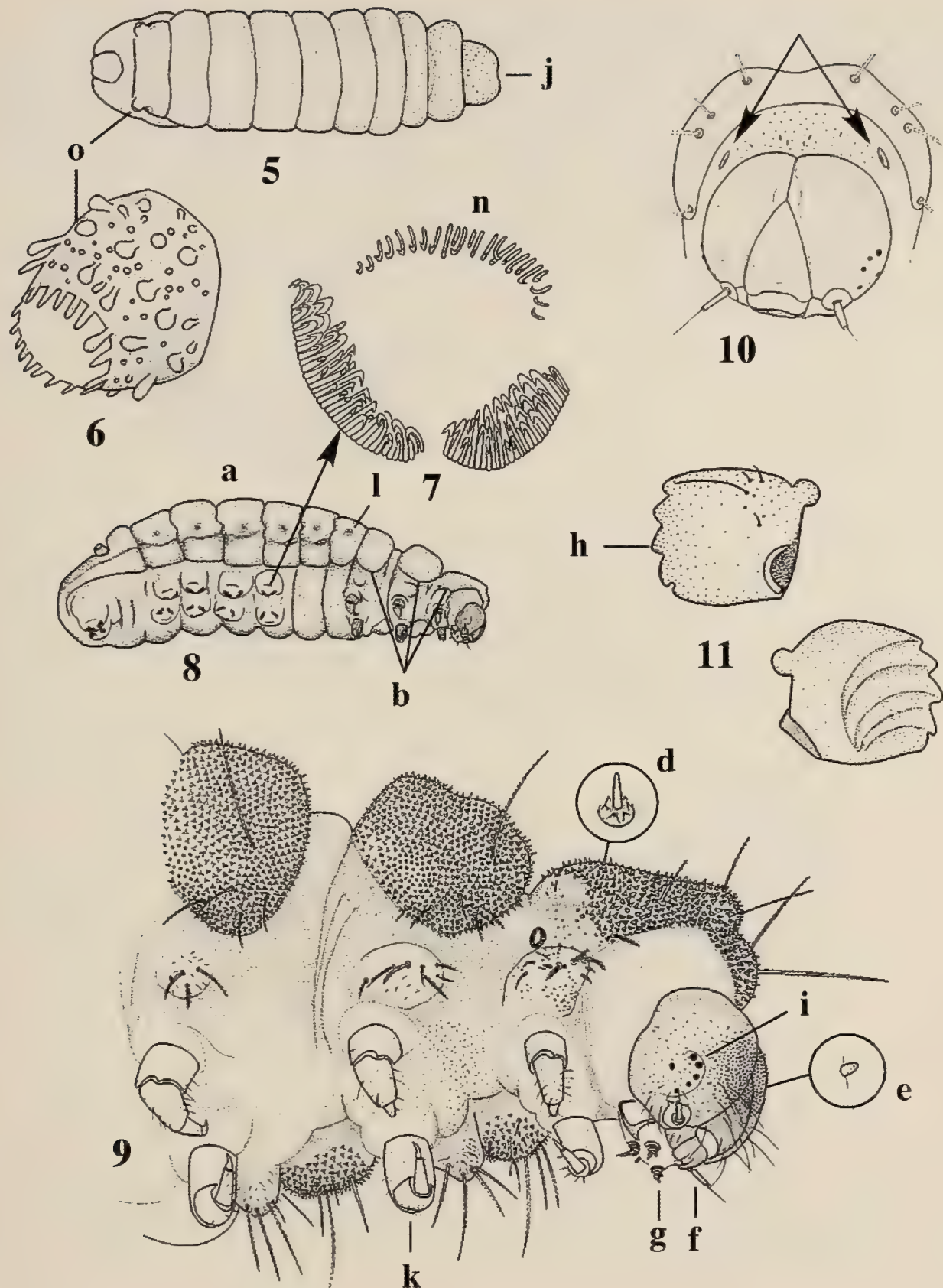
Elsewhere we have described the substrate-borne calls of *A. amesis* caterpillars, noting that the mechanism for call production within the Eurybiini was unknown (DeVries & Penz 2000). Recently Travassos et al. (in press) presented evidence suggesting that *Eurybia elvina* produce a substrate-borne call by grating cervical membrane “teeth” against hemispherical protuberances on the surface of the head. Our examination of *A. amesis* caterpillars with optical microscopy revealed a cervical membrane similar to that described by Travassos et al. (in press) for *E. elvina*—the membrane is armored with “teeth” and bears small setae and rounded protuberances. Moreover, we note the presence of rounded sclerotized areas in the dorsolateral portion of the cervical membrane in *A. amesis* and *E. lycisca*, *E. patrona*, *E. lycisca*, *E. nr. nicaeus* and *E. elvina* (indicated by arrows in Fig. 10). The function of these rounded sclerotized areas is unclear, but their potential role in caterpillar call production warrants further investigation because they occur in proximity to where epicranial granulations are well developed.

Although brief in scope, we hope this study will stimulate comparative life history work on other species of Eurybiini to further our understanding of the biology and evolution of this unusual group of riodinids.

#### ACKNOWLEDGMENTS

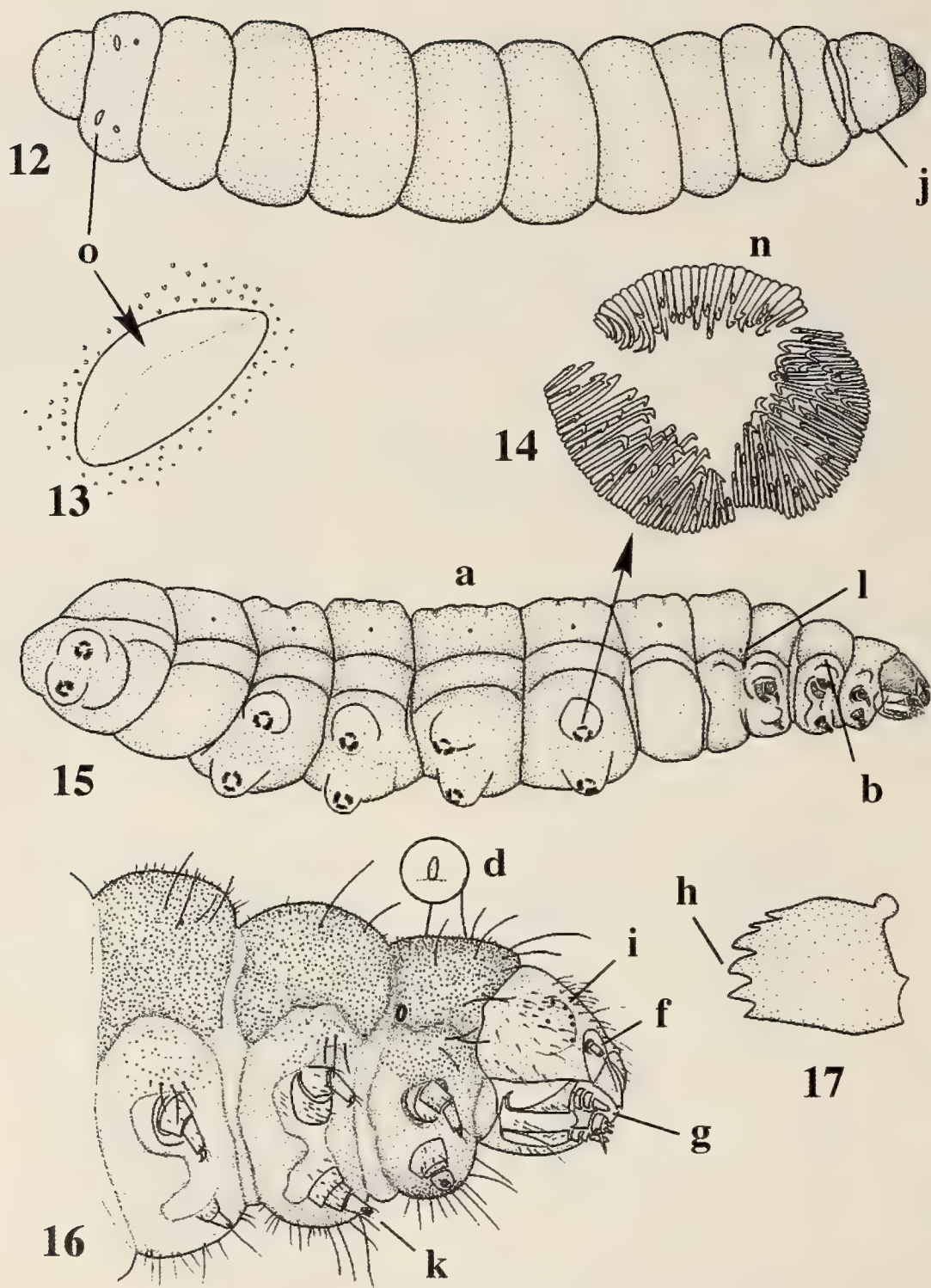
We thank the La Selva Lodge, its staff, and particularly Eric Schwartz for providing strong field support for this and other studies. Comments and suggestions by L. Gall, R. Hill, E. Youngsteadt, D. Wagner and A. Warren improved the manuscript. We thank Museo de Ciencias Naturales (Quito, Ecuador) for assistance in this and other studies. We gratefully acknowledge the help H. Greeney, R. Hill and N. Gerrardo for help in caring for early stages. This study was supported in part by NSF DEB 00-96241. We dedicated this paper to the late Tommy Flanagan, Joe Henderson, and Vinicius de Moraes.





FIGS. 5–11. Details of *Alesa amesis* fifth instar caterpillar. Figs. 5–10 represent the same individual; Fig. 11 dissected from a cast skin. Letters correspond to traits listed in Table 1. **5**, Dorsal view of caterpillar, head oriented to the right. **6**, Tentacle nectary organ. **7**, Crochets of third abdominal proleg. **8**, Caterpillar in ventrolateral view. **9**, Detail of the caterpillar thorax in ventrolateral view, insets show body and head spines. **10**, Detail of caterpillar head and cervical membrane (head setae and body spines omitted), arrows indicate the round sclerotizations present on the cervical membrane. **11**, Outer (top) and inner (bottom) views of left mandible. Letters correspond to details in Table 1, except for “body integument”, and “plantae”.





FIGS. 12–17. Details of *Eurybia patrona* and *E. lycisca* fifth instar caterpillars. Figs. 12–16 represent the same individual *E. patrona* (Barro Colorado Island, Panama); Fig. 17, *E. lycisca* mandible drawn from a cast skin (Parque Nacional Corcovado, Costa Rica). 12, Dorsal view of caterpillar, head oriented to the right. 13, Tentacle nectary organ. 14, Crochets of third abdominal proleg. 15, Caterpillar in ventrolateral view. 16, Detail of the caterpillar thorax in ventrolateral view, inset shows a body spine. 17, Outer view of *E. lycisca* left mandible. Letters correspond to details in Table 1, except for “body integument”, and “plantae”.

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## THE EFFECTS OF SEASON, HOST PLANT PROTECTION, AND ANT PREDATORS ON THE SURVIVAL OF *EUMAEUS ATALA* (LYCAENIDAE) IN RE-ESTABLISHMENTS

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**ABSTRACT.** The primary purpose of this study on *Eumaeus atala*, the atala butterfly, was to determine which factors influence larval survival during re-establishment of atala butterfly populations. An inexpensive protective cover of fabric netting over the host plants at the re-establishment site was found to have a positive effect on the number of larvae that survived to pupation. Season was also found to have an effect on the number of re-established larvae that survived to pupation. Significantly more larvae survived to pupation during the wetter summer season than during the drier winter season. This suggests that future attempts to re-establish the atala should take place in the summer and should consider the use of protective netting over host plants. In the course of this study, the mortality of atala eggs was found to be high, and two new ant predators of atala eggs were found.

**Additional key words:** coontie, cycasin, insect.

The atala, *Eumaeus atala* Poey, is a hairstreak butterfly (Lycaenidae, subfamily Theclinae) with a tumultuous history. It was once considered to be extinct throughout south Florida due to the exploitation of its sole native larval host plant, but the atala has since made a comeback. There are close to 50 lycaenid species in the West Indies and south Florida (Smith et al. 1994). Female atala lay whitish-yellow eggs in clusters of up to thirty eggs which are usually deposited on fresh leaves of cycad species or on their reproductive cones. Atala larvae are a rusty-red color, with seven pairs of canary yellow spots on the dorsal side and short black setae. Their bright coloring is aposematic, as larvae and adults contain cycasin (Bowers & Larin 1989, Nash et al. 1992). Spiders, for example, who find the atala in their webs, avoid them (Hubbuck 1991). The atala apparently concentrate the secondary compounds of their larval host plant, the Florida coontie, *Zamia pumila* (Zamiaceae), in their bodies.

*Eumaeus atala* had a historical range of Dade, Monroe, and Broward counties in Florida. It also ranged throughout Cuba, and into the Bahamas (Clench 1943). In Florida, the atala's current range includes Dade, Broward, Monroe, Palm Beach, Indian River and St. Lucie counties (Culbert 1995). It also still occurs in Cuba, the Bahamas, and Cayman Brac (Hammer 1995).

Early scientific references to the atala describe the species as abundant in south Florida and Cuba (Scudder 1875, Schwartz 1888, Healy 1910, Grossbeck 1917). By the mid-twentieth century, the atala was considered rare or extinct in Florida by lepidopterists (Ford 1946, Klots 1951, Young 1956, Funk 1966, Rawson 1961). In 1979, on Key Biscayne, Florida, Miami-Dade county naturalist Roger Hammer found a thriving colony of *Eumaeus atala* (Roger Hammer pers. com.). Hammer attempted re-establishments, many of which were successful.

Atala multiplied at various locations in South Florida from Coral Gables to Florida City (Landolt 1984). "The atala has made a spectacular recovery and is now found in urban and natural areas around Fort Lauderdale and Miami" (Emmel & Minno 1993). The Key Biscayne colony, however, vanished for unknown reasons around 1991.

The main goal of this project was to conduct an atala re-establishment and to examine three questions. The first was to find out whether season would have an effect on larval and pupal mortality in a re-establishment. The second question was whether protecting atala host plants would increase survivability of larvae. It was hypothesized that if netting were placed over the host plants, more of the translocated larvae would survive compared to larvae on unprotected plants. The third question was are there predators of atala larvae, eggs and pupae, despite their cycasin content. This is important information because despite the fact that re-establishments appear to have preserved the atala in Florida, few details are known about what factors enhance success in re-establishment.

All of the study sites for this project were in Bear Cut Preserve, Crandon Park on Key Biscayne, Florida. Restoration of habitat was necessary prior to attempting atala re-establishment. The coastal maritime hammock where the study took place had been damaged by fire and exotic plant species (Doren et al. 1991). Few coontie plants remained in Crandon Park. Thirty-one coontie plants were purchased and planted in the re-establishment areas to improve the atala habitat prior to this project.

### MATERIALS AND METHODS

Atala translocation to Key Biscayne began in January of 1999. Miami's Fairchild Tropical Garden donated all larvae and pupae used in the re-establishment. Fairchild was chosen as a source since it has the most consistently strong atala population in the county and because its colony originated from the

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1980’s human-established atala colonies. The number of larvae used in releases for this project and the timing of releases themselves were always dependent on the population size of the Fairchild colony.

Atala larvae were all close to the same age at translocation, determined by measurement to be in their second instar. They were removed from the colony at Fairchild Tropical Gardens and placed on *Z. pumila* at four different sites on Key Biscayne with similar plant cover, topography, accessibility to host plants, and light levels. In addition to the larvae placed at these sites in Crandon, corresponding larvae were placed at an off-site location. Larvae were placed in three different treatment situations.

The three different treatments to the larvae were as follows. In Treatment #1, atala larvae were released and placed on *Z. pumila* in Crandon Park in a “natural” release with no treatment. Larvae had no protection from predators, except for their natural defenses. In Treatment #2, larvae were placed on *Z. pumila* in Crandon Park, then covered with a fine green nylon netting fabric that was tightly tied at the base of the plant. Holes in the mesh were 10 mm. Upon pupation of the atala, this netting was removed. In Treatment #3, the larvae were reared in captivity off-site on fresh-cut *Z. pumila* fronds under a high level of protection on a screened porch without temperature control. This third treatment gives an indication of how survival of atala in captive rearing compares to survival in the field.

The attempted re-establishments in Crandon Park and the off-site captive rearing experiments were repeated three times throughout the year: Winter/Dry season, Transitional/Spring season and Summer/Rainy season (see Table 1).

Length of residency was used as a measure of survival for larvae. If a larva was no longer on the host plant or was not discovered pupating on other plants within 1 m of the host plants, it was considered to have died, even if the actual “corpse” was not discovered. Although larvae sometimes leave the host plant to pupate, they tend to do so in clusters and are easily found usually within 1 m of the host plant regardless of whether netting is present. This was reinforced in my experiment at an off-site location on a screened porch where, despite the lack of netting around coontie, 76% of atala larvae did not venture farther than 0.5 m from their point of translocation to pupate. The other 24% of larvae crawled up to 1 m away, but never to a greater distance when sufficient coontie was available, despite there being no barriers to prevent them from doing so. At both the park and the offsite location, while there were other plants surrounding the translo-

TABLE 1. Experiments #1–3: an explanation of atala re-establishments in the dry/winter season, transitional season, and summer/wet Season. Experiment #1 is the Dry/Winter season. Experiment #2 is the Transitional Season. Experiment #3 is the Wet/Summer Season.

Date	Experiment	Total # of larvae	Treatment	Sites released
1/15/99	#1	59	none	1, 2, 3, 4, 5
1/28/99	#1	59	captivity	ex situ
2/16/99	#1	59	netting	1, 2, 3, 4, 5
4/9/99	#2	21	none	2
5/5/99	#2	21	captivity	ex situ
5/5/99	#2	21	netting	2
6/30/99	#3	54	none	1, 2, 5
6/30/99	#3	54	captivity	ex situ
6/30/99	#3	54	netting	1,2,5

cation sites, the only coontie available were those that were part of the experiments.

Pupal mortality was distinguished by presence and condition of the pupae. When an atala butterfly emerges naturally, there is a cleanly consistent ecdys-tal slit in the cuticle. If the pupa has been opened by outside force, this is easy to discern. If the pupa vanished, it was assumed to have been taken by a predator unless discovered in its entirety on the ground beneath the plant on which it pupated.

Ideally, Treatment #1, Treatment #2, and Treatment #3 would all have been initiated simultaneously at the beginning of each of the three seasons. However, larvae were not always available in sufficient numbers at Fairchild, so some of the differing larval treatments in the same experiment were separated by 2–4 week time spans (still within the same season).

The four sites in Crandon Park, sites #1, 2, 3, and 5 were assumed to be similar to one another in plant cover, light level and topography and were used as replicates (Site 4 was removed from the study prior to its onset). Sites 6–13 were off-site captive-rearing sites assumed to be similar to one another and used as replicates.

To address the hypothesis that netting improved the ability of larvae to survive to pupate and the question of whether season impacted larval survival, analyses of variance were performed by treatment and season. Pupal survival to emergence was also examined in these ANOVAs. Tukey’s post hoc test was also performed.

RESULTS

There was no interaction between treatment and season on larval survival to pupation,  $F(4, 15) = 2.30$ ,  $p = 0.107$ . There was also no interaction between treatment and season on survival to emergence,  $F(4, 15) = 0.35$ ,  $p = 0.842$ .



TABLE 2. Main effects of season and treatment on atala pupation and emergence.

Analyses of variance Main effects of	df	F	Significance
TREATMENT on % pupating	(2, 15)	16.13	p < 0.001
TREATMENT on % emerging	(2, 15)	3.08	p < 0.076
SEASON on % pupating	(2, 15)	6.86	p < 0.008

There was a main effect of treatment on pupation, F (2, 15) = 16.13, p < 0.001 (Table 2). Tukey's post hoc test at a 5% significance level demonstrated that the mean percentage of atala pupating with protective netting (62.7%) was significantly greater than the mean percentage pupating without netting (17.1%) (Table 3).

There was also a marginally significant main effect of treatment on emergence, F (2, 15) = 3.08, p < 0.076 (Table 2). Tukey's post hoc test at a 5% significance level revealed that the mean percentage of atala that emerged from their pupae successfully on plants where netting had been applied earlier on (96.9%) was significantly higher than the mean percentage that emerged from their pupae without netting ever having been used (60.8%) (Table 3).

As predicted, there was a significant main effect of season, F (2, 15) = 6.86, p < 0.008 (Table 2). Tukey's post hoc test indicated that Season #3/Summer had a significantly higher percentage (56.8%) of pupation than Season #1/Winter (33.2%) (Table 3).

Few predators of the atala in any of its life stages have ever been reported. In the course of this study, several ant species were found to be major predators on atala in the egg stage, and one species was found to enter pupae. The first ant species noted as an egg predator was *Camponotus abdominalis* var. *floridana*. This is a common native ant in Florida that often infests dwellings. Also called "bull dog" ants, they are known to feed on honeydew and insects (Smith 1972). In prior lab feeding trials, atala adults and cycasin were considered deterrents to *C. abdominalis* (Bowers & Larin 1989).

The same species of ant was observed at Site #2 in Crandon on 4 June 1999 tearing apart atala eggs where 19 eggs had been laid. At the same time, an atala butterfly was fluttering around the plant in a pattern typical of an egg-laying female. The butterfly got very close to the frond where the ant was eating eggs, and beat at the ant with its wings. The ant grabbed an antenna of the atala butterfly and pulled. There was a fierce struggle, and the butterfly fell to the ground. The atala beat its wings on the ground, momentarily unable to fly, then flew away quickly. This unusual behavior appeared to be very purposeful on the part of the atala, as if it were attempting to drive the ant away from its offspring.

TABLE 3. Tukey's post hoc test at 5% level: mean percentage of atala pupation and emergence by treatment group and by season.

	Mean % pupating:	Mean % emerging:
BY TREATMENT GROUP		
#1 Group (with No Treatment) <sup>a</sup>	17.1%	60.8%
#2 Group (with Medium Treatment/Protection Level) <sup>b</sup>	62.7%	96.9%
#3 Group (with High Protection) <sup>c</sup>	54.7%	96.7%
Significant difference:		
Group #1 <sup>a</sup> vs. #2 <sup>b</sup>	p < 0.001	p < 0.046
Group #2 <sup>b</sup> vs. #3 <sup>c</sup>	n.s.	n.s.
Group #1 <sup>a</sup> vs. #3 <sup>c</sup>	p < 0.001	p < 0.047
BY SEASON		
#1 Season <sup>d</sup>	33.2%	82.3%
#2 Season <sup>e</sup>	55.6%	84.6%
#3 Season <sup>f</sup>	56.8%	88.2%
Significant difference:		
Season #1 <sup>d</sup> vs. #3 <sup>f</sup>	p < 0.009	n.s.
Season #1 <sup>d</sup> vs. #2 <sup>e</sup>	n.s.	n.s.
Season #3 <sup>f</sup> vs. #2 <sup>e</sup>	n.s.	n.s.

<sup>a</sup> In situ without netting on plants  
<sup>b</sup> In situ with netting on plants  
<sup>c</sup> Ex situ in captivity (outside cages)  
<sup>d</sup> Winter/Dry Season  
<sup>e</sup> Transitional/Spring Season  
<sup>f</sup> Summer/Rainy Season  
n.s. = no significance, p > 0.05.

It took a *Camponotus* ant very little time to find atala eggs. On 30 August 1999, a single ant was observed at Site #2 at 13:32 on a coontie frond while an atala was laying eggs. The ant came near enough to the six eggs to attack them, but did not, then turned around and left the plant. Ten minutes later, another ant (possibly the same one) appeared and began to tear a hole in the eggs. Within eighteen minutes of the egg-laying event, three other ants of the same species arrived and began a new attack on the eggs, until all six were destroyed.

On 5 July 1999 a large ant (*Pseudomyrmex mexicanus*) was observed attacking atala eggs at Site #2 where 25 eggs had been laid. Nine undisturbed pupae were also present on the same plant. *Pseudomyrmex mexicanus* is native and found throughout the eastern United States (Smith 1972).

Another egg predator was observed during a survey at Rockdale Pineland in Miami on 3 October 1999. *Wasmannia auropunctata* (Roger) spent 15 min puncturing a small hole in an egg before the ant was collected. Commonly known as the "little fire ant," *W. auropunctata* is a neotropical ant introduced into Florida (Smith 1972).

For several weeks, pupae would occasionally be found in Crandon Park with a perfectly round 0.1 cm diameter hole in the outer layer. Several times, upon examination, tiny ants (*Monomorium floricola*) spilled





FIG. 1. A female *Eumaeus atala* (atata butterfly) depositing eggs on a *Zamia pumila* (coontie) frond. Photograph by Robert Schroeder (used with permission).

out of the holes. *Monomorium floricola* is an introduced ant from Africa or Asia, known to feed on insects (Smith 1972). These ants may have been opportunists who went into holes made by a parasite.

In Bear Cut Preserve, Crandon Park, ants appeared to be a major cause of egg mortality and had a serious effect on atala survival. Ants left visual evidence behind in the form of characteristic broken and torn apart eggshells. Ants were also observed, less commonly, carrying eggs away from the plant. Over 700 atala eggs were observed to have been laid in Crandon Park. Of these, 131 were destroyed in a manner that implicated ants and at least the same number of eggs simply vanished.

#### DISCUSSION

The results of this re-establishment provide input for a plan of successful re-establishment of the atala. The survival of translocated larvae was greatly enhanced by a simple and inexpensive protective netting treatment that affords extra protection in the vulnerable larval stage. Survival of these protected in situ larvae was equivalent to the survival of highly protected captive-reared larvae. It is therefore recommended that atala re-establishments use protective netting to

cover larvae and plants until at least pupation. Re-establishment utilizing pupae rather than larvae should also be tested, since once atala pupate, survival is quite high, even without netting protection.

As soon as all larvae in the experiments had pupated, the netting was removed, so the use of netting might not necessarily be expected to affect the percentage of atala that survived from pupation to emergence. Despite this, there was marginal significance, with more butterflies successfully emerging from pupae that had been protected by netting in their larval stage. Further testing should be conducted to determine how the netting utilized in the larval stage may enhance future pupal survival.

Larval survival was highest in the summer. The summer season is also the wettest. It is a logical outcome since during the rainy season, there are more fresh coontie fronds available, which are the favored food of early instars. During the dry season, the young atala caterpillars must work harder to survive, scraping at the underside of old, tougher fronds. Re-establishments of the atala appear to have a much greater chance of success when conducted in the summer rainy season.

Egg protection must be factored into the re-



establishment equation. The impact of native and exotic ant species on the atala requires a detailed examination. Finer netting, placed over eggs as soon as possible, may discourage these and other predators.

Re-establishment of the atala into habitat where it was once common, but has been locally extirpated, is possible with a limited time commitment and limited financial investment, and the results appear to be very promising. The re-established atala colony on Key Biscayne, with no translocations having been done since June of 1999, was still abundant at the time of the last survey by this researcher in November of 2001.

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A NEW SPECIES OF *EPIBLEMA* PREVIOUSLY CONFUSED WITH *E. TRIPARTITANA* (ZELLER) AND  
*E. INFELIX* HEINRICH (TORTRICIDAE)

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**ABSTRACT.** *Epiblema glenni*, new species, is described from 36 adult specimens (29 ♂, 7 ♀). This species frequently has been misidentified as *E. tripartitana* (Zeller), its closest congener, from which it differs in details of forewing maculation. Records of *E. glenni* from seven states suggest a range extending from central Missouri to western North Carolina and north to central Michigan. A rather long history of confusion involving *E. glenni*, *E. tripartitana*, *E. infelix* Heinrich, and *E. scudderiana* (Clemens) is reviewed. Adults and genitalia (♂ and ♀) of all four taxa are illustrated.

**Additional key words:** Olethreutinae, Eucosmini, *Epiblema scudderiana*.

About one-third of the 40 recognized species of *Epiblema* (Hübner) in North America feature a predominantly dark forewing with a prominent whitish spot at the middle of the dorsal margin. One of the more conspicuously marked members of this group is *E. tripartitana* (Zeller), whose spot extends from the dorsal margin to the costa, forming a broad transverse band that completely separates the dark basal and terminal portions of the forewing.

While surveying remnant prairie habitat in Adams County, Ohio, I encountered a new species of *Epiblema* with forewing markings that are similar to yet clearly distinguishable from those of *E. tripartitana*. Investigation turned up additional representatives of this species, collected in the 1960's by Murray O. Glenn in Putnam County, Illinois, and mixed in two public collections with specimens of *E. tripartitana*. I could find no consistent differences in male genitalia between the new species and *tripartitana*, and preparations of neither matched Heinrich's (1923, Fig. 270) illustration of the latter species. The reason for this discrepancy proved to be a misinterpretation by Heinrich of several specimens from Florida. The holotype of *tripartitana* is a female from Dallas, Texas. Heinrich's (1923:146) treatment of this species refers to a series of specimens from Texas and Florida, and he illustrated the genitalia of a male from Cocanut Grove, Florida. Examination of that specimen and of a number of similarly marked specimens from nearby Florida localities revealed that they are not conspecific with *tripartitana*. They agree in both male and female genitalia with *Epiblema scudderiana* (Clemens). Their forewing coloration is sufficiently near that of *tripartitana* to cause the aforementioned confusion, but the basic forewing pattern does match that of *scudderiana*. Moreover, I found a reared specimen of this species from Savannah, Georgia, labeled "Goldenrod stem borer," suggesting that it shares a common life history with *scudderiana*. For these reasons, I decided to treat the Florida specimens as representing a darkly marked population of *scudderiana*. Intraspecific variation in *scudderiana* is discussed below.

The proper application of the name *tripartitana* was confirmed by examining the holotype. In studying material from various collections I discovered that the new species also has been confused with *E. infelix* Heinrich, so an account of *infelix* is included for diagnostic purposes.

MATERIALS AND METHODS

I examined specimens from the following institutional and personal collections: American Museum of Natural History (AMNH), George J. Balogh (GJB), University of Connecticut (UConn), Loran D. Gibson (LDG), Illinois Natural History Survey (INHS), University of Louisville (UL), Michigan State University (MSU), Mississippi Entomological Museum (MEM), Museum of Comparative Zoology (MCZ), Ohio Lepidopterists (OL), United States National Museum of Natural History (USNM), James R. Wiker, and Donald J. Wright (DJW). Other cited collectors are abbreviated as follows: Julian P. Donahue (JPD), E. H. Metzler (EHM), Murray O. Glenn (MOG). Line drawings were made with the aid of a Ken-A-Vision microprojector (Model X1000-1). Terminology regarding forewing pattern elements follows Brown and Powell (1991). Forewing length was measured from base to apex, including fringe, and the number of specimens supporting a particular statistic is indicated by n.

SYSTEMATICS

*Epiblema tripartitana* (Zeller)  
(Figs. 2, 5, 12, 16)

*Paedisca tripartitana* Zeller 1875:308, pl. 9, Fig. 39 (forewing).

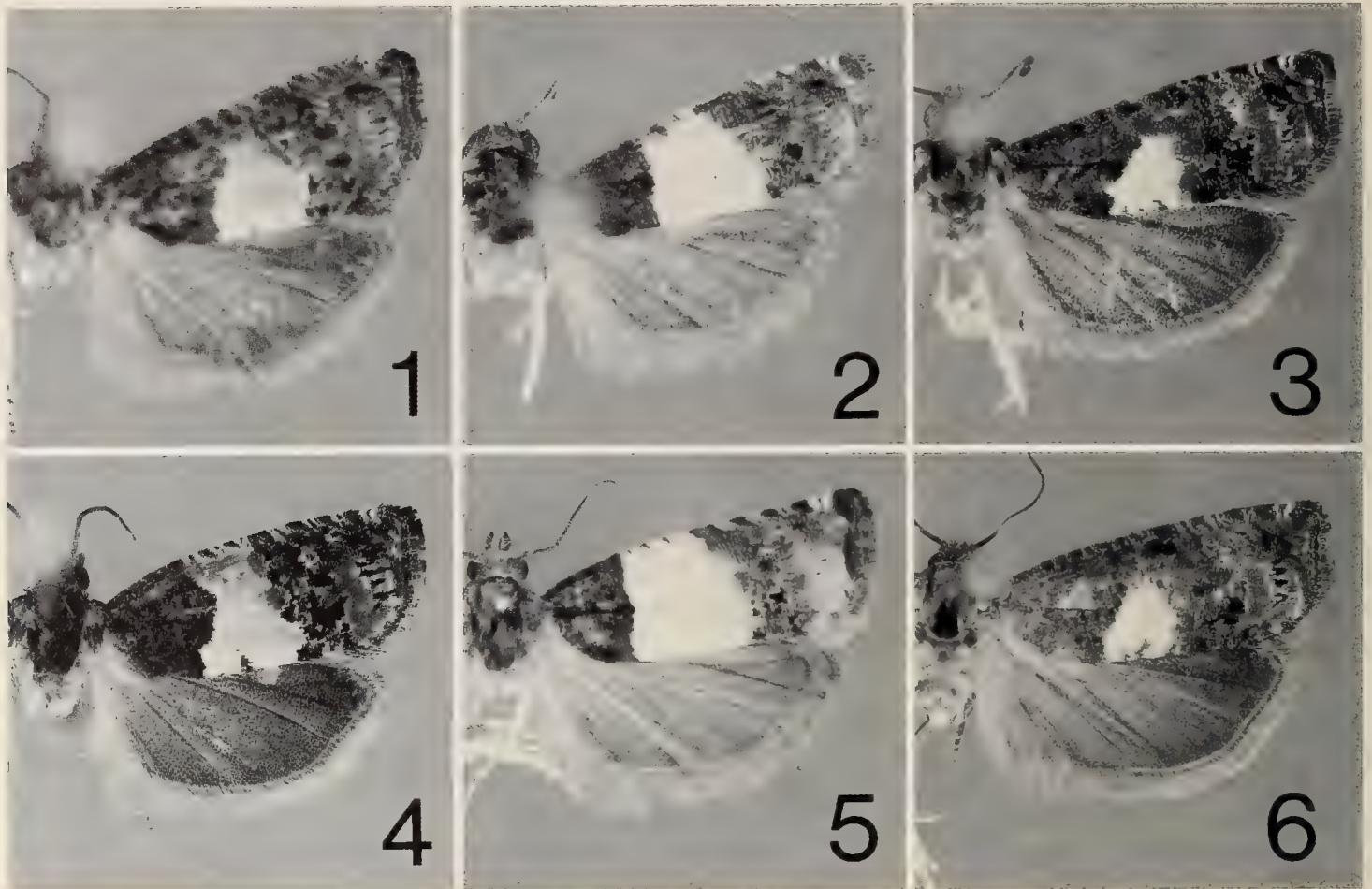
*Eucosma tripartitana* Fernald [1903]:459; Barnes and McDunnough 1917:171.

*Epiblema tripartitana* (not Zeller 1875) Heinrich 1923:146; Kimball 1965:260.

*Epiblema tripartitana* McDunnough 1939:48; Powell 1983:35; Miller 1987:57 (wings, ♂ & ♀ genitalia).

**Holotype.** ♀: Dallas, Tex., Boll; MCZ Type No. 14337.





FIGS. 1-6. 1. *E. glenni*, holotype male, Adams Co., Ohio. 2. *E. tripartitana*, male, Ithaca, New York. 3. *E. infelix*, male, Laurel Co., Kentucky. 4. *E. glenni*, female, Adams Co., Ohio. 5. *E. tripartitana*, female, Morton Co., Kansas. 6. *E. infelix*, female, Laurel Co., Kentucky.

**Remarks.** In describing the forewing of *Paedisca tripartitana*, Zeller (1875) indicated that the interfascial spot extends from the dorsal margin to the costa and is unmarked except for about six very short diagonal lines along the costa. The lines to which he refers are dashes of ground color delimiting the costal strigulae. He also noted that the dorsal edge of the spot is considerably wider than the costal edge and that the spot's distal margin is convex.

Heinrich (1923) misidentified as *E. tripartitana* some darkly marked Florida specimens of *E. scudderiana*, and his illustration of *tripartitana* male genitalia (Fig. 270) is based on one of those specimens. Apparently he also was referring to the Florida specimens when he wrote the diagnostic couplet (no. 11) for *tripartitana* in his key (p. 137). There he characterized the interfascial spot as "extending nearly to costa," which is descriptive of the Florida specimens but is not accurate for *tripartitana*.

*Epiblema tripartitana* has been recorded from Florida, but the account in Kimball (1965) must be viewed with caution. My attempts to match his data with museum specimens always resulted in the darkly marked form of *scudderiana*.

I examined material from Colorado, Connecticut, Florida, Illinois, Iowa, Kansas, Louisiana, Michigan, Mississippi, Missouri, New Mexico, New York, Ohio, and Texas. Forewing length varied considerably: ♂ 4.0-7.5 mm (mean = 5.7,  $n = 17$ ), ♀ 5.5-10.0 mm (mean = 6.7,  $n = 14$ ). The upper extremes corresponded to individuals from east Texas reared by Bottimer (1926). The maculation of *E. tripartitana* exhibits a certain amount of geographic variation. The terminal portion of the forewing usually appears dull brown to blackish brown. However, in a small sample from Colorado, Iowa, Kansas, and New Mexico, the apical area was strongly suffused with light gray, the ocellus was poorly defined, and the area above the toral angle was conspicuously white.

**Biology.** *Epiblema tripartitana* flies from early April to early August, the April and May records being from New Mexico or states bordering the Gulf of Mexico. Bottimer (1926) reported *Rudbeckia maxima* Nuttall as a larval host in east Texas. He observed early larval development in the central part of the flower head, overwintering of the larva and subsequent pupation in the stem at the base of the plant, and spring emergence of the adult.





FIGS. 7–10. *E. scudderiana*. 7. Male, Erie Co., Ohio. 8. Female, Morton Co., Kansas. 9. Male, Bossier Parish, Louisiana. 10. Female, Manatee Co., Florida.

***Epiblema glenni* D. J. Wright, new species**  
(Figs. 1, 4, 11, 15)

*Epiblema infelix* (not Heinrich 1923) Miller 1987:58 (part) (wings, ♂ genitalia).

**Description.** Head: Frons white, scales short and closely appressed; vertex dark brown, often shading to tan anteriorly; outer and ventral surfaces of labial palpus brown, inner and dorsal surfaces white to tan, apex of third segment tan; antenna dark brown above, edged with light tan posteriorly, ventral surface pubescent; ventral surface of scape with varying amounts of white to tan scaling. Thorax: Dorsal surface blackish brown, ventral surface light tan to dull white; legs dark

brown outwardly, light tan inwardly, with light tan tarsal annulations. Forewing (Figs. 1, 4): ♂ length 5.0–8.5 mm (mean = 6.1,  $n = 37$ ), ♀ length 5.6–8.6 mm (mean = 6.6,  $n = 7$ ); costa nearly straight in males, weakly convex basally in females; termen straight to weakly concave from  $M_3$  to  $R_5$ ; male costal fold extending from base to approximately  $0.6 \times$  length of forewing. Upper surface with salmon colored interfascial spot on dorsal margin, in males extending forward to just short of costal fold and separated therefrom by narrow strip of dark gray scales, in females extending to costa and merging there with whitish to salmon colored costal strigulae; interfascial spot roughly rectangular from dorsal margin to fold, constricting abruptly





FIG. 11. Male genitalia, *E. glenni*, slide DJW 631 (DJW), scale bar 0.5 mm.

above fold to approximately half its dorsal width, its basal margin thinly and intermittently lined with white, its dorsal margin with one to three small black marks, the latter sometimes weakly expressed or absent. Central field of ocellus brown to whitish tan, crossed longitudinally by four black dashes, capped at apical corner with a black spot of variable expression, strongly bordered with gray along basal and tornal margins, much more weakly so along distal margin, gray border overlaid to varying degrees with light-brown to pale-salmon scales. Basal patch blackish brown, variously overlaid with gray; male costal fold blackish brown with dark gray costal strigulae; median area with black spot on basal margin of ocellus just above fold, a small gray spot above fold on distal margin of interfascial spot, and otherwise marked with varying black, brown and gray blotches. Costal area beyond interfascial spot brown to blackish brown, crossed by four paired white costal strigulae and their associated gray stria, the latter running outwardly toward ocellus and termen; terminal edge of membrane lined with white-tipped blackish-gray scales and separated from distal margin of ocellus by narrow strip of brown to orange-brown scales; fringe dark blackish gray apically, lighter and sometimes brownish at tornus. Hindwing: Uniformly grayish brown; fringe a

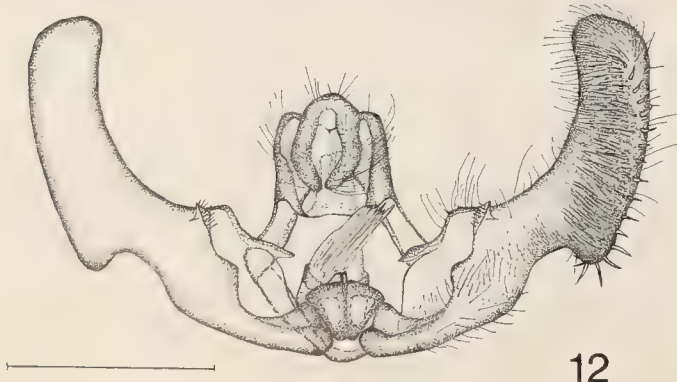


FIG. 12. Male genitalia, *E. tripartitana*, slide DJW 645 (MEM), scale bar 0.5 mm.

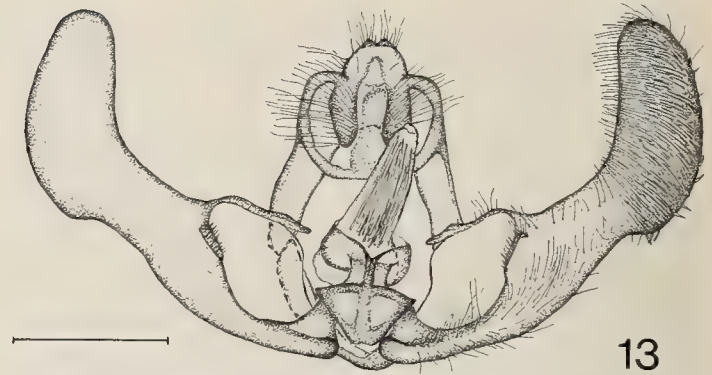


FIG. 13. Male genitalia, *E. infelix*, slide DJW 755 (USNM), scale bar 0.5 mm.

shade lighter. Male genitalia (Fig. 11): Uncus convex and dorsally setose, supported laterally by moderately developed shoulders; socii fingerlike, flattened, moderately long, and covered with long hairlike setae; gnathos a narrow sclerotized band, expanded medially; aedeagus with approximately 25 deciduous cornuti; juxta triangular; caulis short; costal margin of valva concave, outer margin weakly convex, inner and outer margins of apical one-third of cucullus nearly parallel, apex truncated, with rounded corners, invagination of ventral margin narrow, width of neck approximately one-half that of saccus, ventral angle acutely rounded; margin of basal opening of saccus featuring prominent basal projection with rounded vertex and nearly perpendicular sides; clasper mounted on margin of basal opening above projection; ventral margin of saccus sparsely setose basally, more densely and heavily setose at neck; cucullus densely covered with stout setae on distal one-half of inner surface from ventral angle to three-fourths distance to apex, outer line of setae following distal margin of cucullus to one-half distance to apex and migrating thereafter onto inner surface; apical one-fourth of cucullus densely covered with hairlike setae. Female genitalia (Fig. 15): Papillae anales narrow, laterally facing, densely setose; tergum VIII sparsely setose; anterior and lateral edges of sterigma forming U-shaped collar, lamella postvaginalis well developed, gradually widening posteriorly,



FIG. 14. Male genitalia, *E. scudderiana*, slide DJW 198 (USNM), scale bar 0.5 mm.



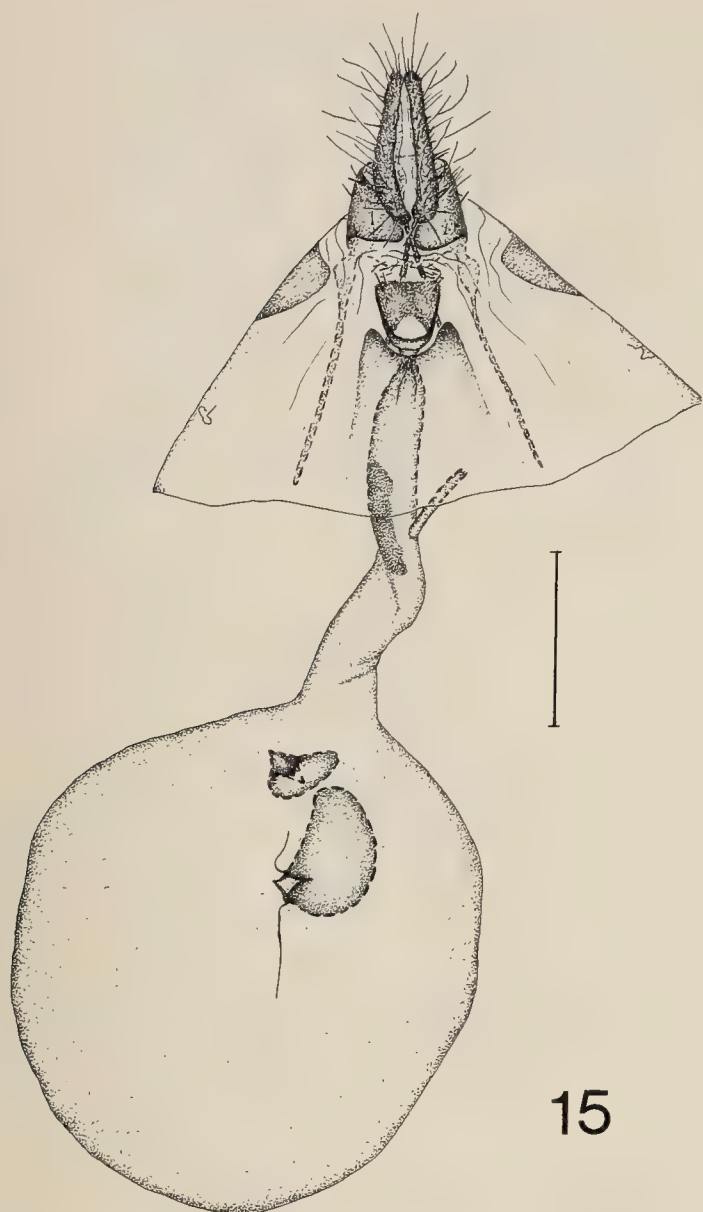


FIG. 15. Female genitalia, *E. glenni*, slide DJW 644 (DJW), scale bar 0.5 mm.

variably setose at the posterolateral corners, posterior margin straight, anterior margin  $\Lambda$ -shaped; posterior margin of sternum VII narrow, roundly invaginated to depth of  $0.3 \times$  length of sterigma, closely approximate to sterigma throughout; ductus bursae uniformly narrow, constricted below ostium, with long sclerotized patch opposite and posterior to juncture with ductus seminalis; corpus bursae with two signa shaped as in Fig. 16, one roughly twice the size of the other, the larger arising from ventral surface just above mid-bursa, the smaller from dorsal surface near juncture with ductus bursae.

**Holotype.** ♂: OH [Ohio]: Adams Co., 1 mi. S. E. of Lynx, August 12, 1998, leg. D. J. Wright; genitalia slide DJW 631; deposited in USNM. Type locality:  $38^{\circ}47'37''\text{N}$ ,  $83^{\circ}24'19''\text{W}$ .

**Paratypes.** ILLINOIS: Putnam Co., 17 June 1955, MOG (1 ♀), 8 July 1965, MOG (1 ♂), 14 July 1968,

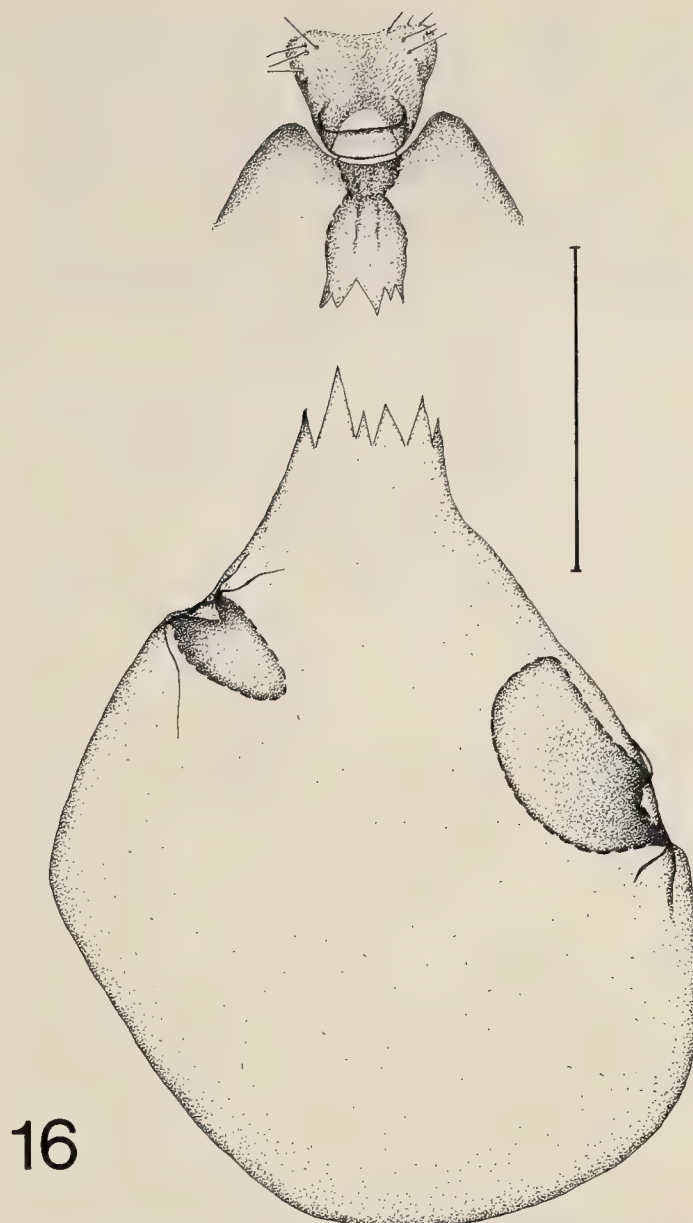


FIG. 16. Female genitalia, *E. tripartitana*, sterigma and lateral view of corpus bursae, slide DJW 751 (DJW), scale bar 0.5 mm.

MOG (1 ♂), 20 July 1968, MOG (1 ♂), 21 July 1965, MOG (1 ♀; genitalia slide DJW 344). KENTUCKY: Laurel Co., DBNF, Powerline cut W side Marsh Branch Rd, 25 July 1997, LDG (1 ♂). MICHIGAN: Barry Co., T3N R10W S22, 6 June 1968, JPD (1 ♂; genitalia slide PB 198), T3N R10W S3, 12 June 1987, GJB (1 ♂). MISSOURI: Reynolds Co., Grasshopper Hollow, Prairie Fen (TNC), 16 September 1996, GJB (1 ♀; genitalia slide DJW 346); St. Francois Co., St. Francois St. Pk. along Coonville Creek, 10 July 1982, GJB (1 ♀). OHIO: Adams Co., 1 mi. SE of Lynx, 25 July 1998, DJW (1 ♀; genitalia slide DJW 630), 1 August 1997, DJW (1 ♂; genitalia slide DJW 643), 3 August 1998, DJW (2 ♂), 3 August 2000, DJW (5 ♂), 12 August 1998, (7 ♂, 2 ♀; ♂ genitalia slides DJW 458, 632, ♀ genitalia slides DJW 457, 644), 21 August 1993, DJW (1 ♂; genitalia slide DJW 323), 10 September 1988, DJW (1 ♂; genitalia slide DJW 172), Lynx Prairie



#2, 10 September 1988, LDG (1 ♂; genitalia slide LDG 87); Erie Co., Resthaven Wildlife Area, 13 July 1991, LDG (1 ♂); Greene Co., Wright-Patterson Air Force Base, Huffman Prairie, Site G-3, 24 July 1992, EHM (1 ♂); Hamilton Co., Cincinnati, 3349 Morrison Ave., 24 July 1997, DJW (1 ♂); Scioto Co., Brushy Fork near Upper Twin Creek, 26 May 1990, DJW (1 ♂; genitalia slide DJW 347). Paratype depositories: AMNH, GJB, UConn, LDG, INHS, UL, MSU, MEM, MCZ, OL, USNM, DJW.

**Etymology.** This species is named in honor of the late Murray O. Glenn, in recognition of his contribution to the knowledge of the microlepidoptera of central Illinois.

**Distribution and biology.** The sample of 78 specimens from Illinois, Kentucky, Michigan, Missouri, North Carolina, Ohio, and Tennessee indicates a flight period from late May to mid September, but three-fourths of those records occurred between mid July and mid September. No larval host has been recorded.

**Diagnosis.** *Epiblema glenni* differs from *E. tripartitana* in the shape and coloration of the interfascial spot. In *E. tripartitana* the spot appears white to the naked eye, but a pale salmon tint usually is detectable under magnification. In females the spot merges with the costal stigulae, forming a continuous band from dorsal margin to costa; in males it is intercepted by the costal fold, but light-gray to gray costal strigulae on the adjacent portion of the fold often create the impression that it continues to the costal margin. The convex curvature of its distal margin varies from circular to that of a line bent just above the fold. In *E. glenni* the interfascial spot is distinctly salmon colored. Its width narrows markedly above the fold, where the distal edge angles abruptly inward. In females it continues forward to the costa as a narrower band; in males it is separated from the costal fold by a narrow strip of dark scales. I was unable to find characters of the male or female genitalia that would separate the two species. Although Figs. 11 and 12 suggest subtle differences in the shape of the cucullus, this feature is variable in both species and unreliable for diagnostic purposes.

*Epiblema infelix* Heinrich  
(Figs. 3, 6, 13, 17)

*Epiblema infelix* Heinrich 1923:151, Fig. 276 (genitalia of ♂ holotype); McDunnough 1939:48; Powell 1983:35; Miller 1987:58 (part) (♀ genitalia).

**Holotype.** ♂: Fiske Coll., 25 May 1904, Tryon, N.C.; USNM Type No. 24828; genitalia slide USNM 72880.

**Paratypes.** NORTH CAROLINA: Tryon, 4 July 1904, Fiske (1 ♀; genitalia slide USNM 70802), 5 July 1904, Fiske (1 ♂; genitalia slide USNM 70801).

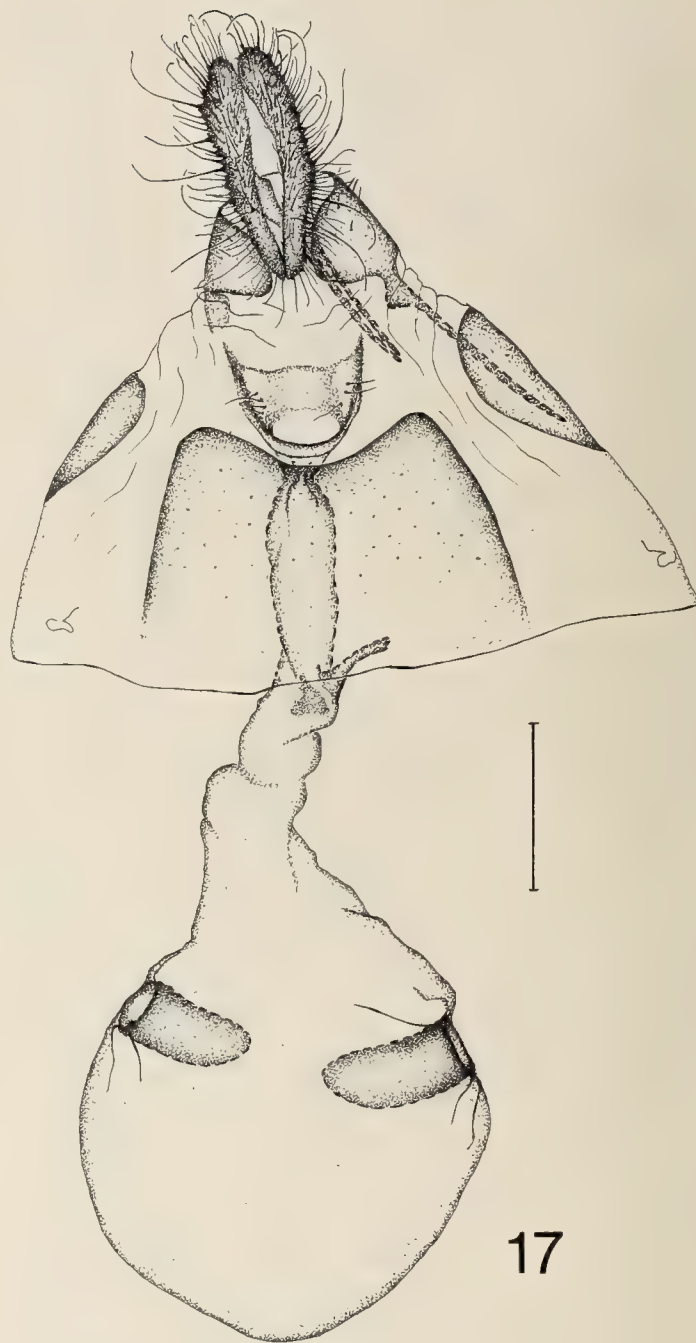


FIG. 17. Female genitalia, *E. infelix*, left apophysis anterior omitted for clarity, slide DJW 677 (MEM), scale bar 0.5 mm.

**Remarks.** *Epiblema infelix* has been a source of confusion for some time. It is poorly represented in institutional collections, and I often found mixed series in the material that I borrowed. I examined the Michigan specimen pictured in Miller (1987:58) as *E. infelix* and found it to be *E. glenni*. Miller's drawing of the male genitalia is representative of *glenni*, but his illustration of the female sterigma is based on the paratype of *infelix* from North Carolina (Miller pers. com.).



Heinrich's description portrays the forewing color as brownish ochreous and the white interfascial spot as irregularly square, with one or two short fuscous dashes on the dorsal margin. Based on an examination of 45 specimens, including the holotype and both paratypes, I would characterize the predominant hue of the forewing as gray, but worn specimens tend to have a brownish appearance. The basal area is rather dark, appearing blackish gray to the naked eye. The white interfascial spot is roughly triangular, extending from the dorsal margin forward to approximately two-thirds the distance to the costa. Its sharply defined basal edge angles obliquely outward from the dorsal margin and often contains a small, basally directed, triangular projection just forward of the dorsal margin. The distal edge is less well defined, the outer vertex on the dorsal margin being irregularly truncated. The interfascial spot is invaded from the dorsal margin by one to three dark marks, which vary considerably in degree of expression. Orange-brown coloration occurs in the costal area beyond the interfascial spot and along the distal edge of the ocellus, the former area being crossed by four paired costal strigulae and their associated gray stria. Forewing length varied as follows: ♂ 6.2–8.7 mm (mean = 7.6,  $n = 20$ ), ♀ 9.5–10.2 mm (mean = 9.8,  $n = 4$ ). The male costal fold extends from base to approximately  $0.5 \times$  length of forewing.

**Distribution and biology.** I studied specimens from Alabama, Arkansas, Kentucky, Michigan, Mississippi, North Carolina, South Carolina, and Virginia. Except for one North Carolina record dated 22 October, they indicate a flight period from early April to early July. Eighty percent of the records occurred between mid April and mid June. No larval host has been recorded.

*Epiblema scudderiana* (Clemens)  
(Figs. 7–10, 14, 18)

*Hedya scudderiana* Clemens 1860:358.

*Euryptychia saligneana* Clemens 1865:141.

*Paedisca affusana* Zeller 1875:307.

*Eucosma scudderiana* Fernald [1903]:459; Barnes and McDunnough 1917:171.

*Epiblema scudderiana* Heinrich 1923:147; McDunnough 1939:48; Powell 1983:35; Miller 1987:57 (wings, ♂ and ♀ genitalia).

**Lectotype.** *Hedya scudderiana*, designated by Darlington (1947:95). ♂: Type 7215, *Paedisca scudderiana* Clem.; Academy of Natural Sciences of Philadelphia. Type locality: Massachusetts. Miller (1973: Fig. 40) provides a photograph of this specimen and a discussion of the type fixation difficulties associated with Clemens' species.

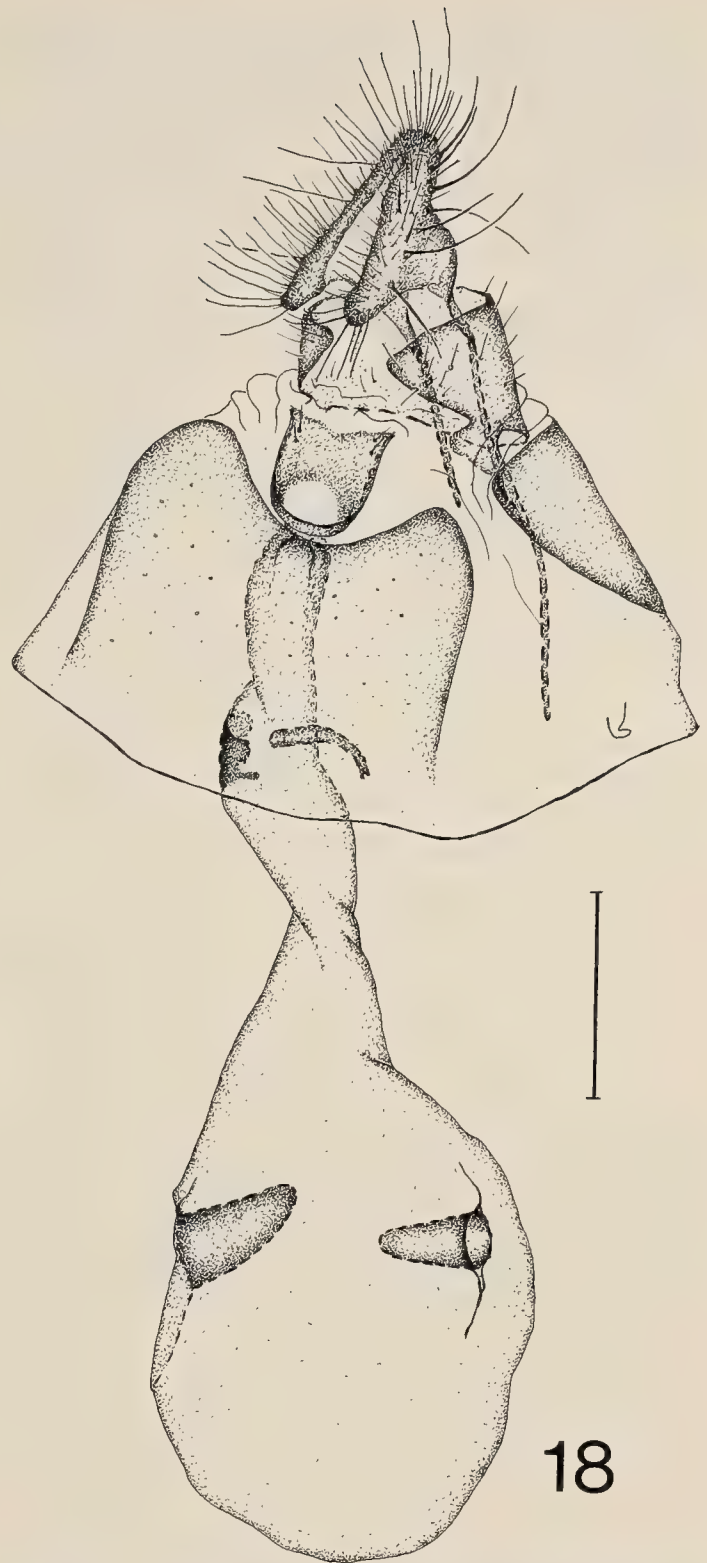


FIG. 18. Female genitalia, *E. scudderiana*, left apophysis anterior omitted for clarity, slide DJW 647 (INHS), scale bar 0.5 mm.

**Remarks.** The basic forewing pattern of *E. scudderiana* has the following features: basal patch blackish brown, variably overlaid with blue-gray scales; interfascial spot white, often marked with varying amounts of blue-gray scaling, extending from dorsal margin to just short of costa, its basal and distal margins roughly convex, producing a bulletlike shape; ocellus crossed longitudinally by up to four black dashes and variably



bordered on basal, distal and tornal margins with blue-gray scales; a narrow band of orange-brown coloration along costa beyond interfascial spot, crossed by four paired white costal strigulae, the latter with associated blue-gray stria running distally toward ocellus and termen; median area with prominent black spot just above fold on basal edge of ocellus and a variably expressed blue-gray band along distal margin of interfascial spot. There is considerable variation in the amount of contrast between interfascial spot and median area and in the coloration of the ocellus. In the Florida population that Heinrich mistook for *tripartitana*, the interfascial spot is nearly immaculate, the median area is dark brown, with little if any white scaling, and the central field of the ocellus is tan to brown. At the other extreme, specimens from the upper Midwest feature an interfascial spot that is moderately speckled with blue gray, a median area that is covered predominantly with white and bluish-gray scales, creating a mottled pale gray appearance to the naked eye, and an ocellus with a white central field. The study sample of 93 specimens included numerous intermediates from various locations, including Florida, New England, and the Gulf coast.

I examined male and female genitalia preparations of specimens representative of the range of the insect and found the following characters most useful for diagnostic purposes. Males ( $n = 14$ ): Uncus semicircular, dorsally setose, supported laterally by well developed shoulders; socii short, fingerlike, flattened, and moderately setose; costal margin of valva concave, outer margin convex, invagination of ventral margin broad and shallow, ventral angle gently rounded; margin of basal opening of sacculus strongly sinuate; inner surface of cucullus sparsely covered on basal one-third with hair-like setae, densely so on distal two-thirds with stouter setae. Females ( $n = 17$ ): Papillae anales narrow, laterally facing and strongly setose; anterior and lateral margins of sterigma forming U-shaped collar, its parallel sides flaring posteriorly; lamella postvaginalis well developed, with semicircular anterior margin and up to five setae on each lateral margin; posterior margin of sternum VII broad, concavely invaginated to depth of  $0.5 \times$  length of sterigma, approximate to ostium medially, diverging from sterigma laterally; ductus bursae tapering gradually, constricted just below ostium, and mildly sclerotized opposite juncture with ductus seminalis; corpus bursae with two cone-shaped signa of nearly equal size, positioned opposite one another at roughly mid-bursa. Figures 14 and 18 are typical of the dark population from Florida. Other genitalia illustrations can be found in Heinrich (1923, Figs. 270 (labeled *tripartitana*) and 271) and Miller (1987:57).

**Distribution and biology.** *Epiblema scudderiana* occurs across the eastern half of the United States and southern Canada. I examined specimens from Alabama, Florida, Georgia, Iowa, Kansas, Louisiana, Massachusetts, Mississippi, New York, North Carolina, Ohio, and Vermont. The larva is known to be a late-instar stem feeder on various species of *Solidago*, where it produces a conspicuous gall. Miller (1976) reports on the biology of this insect, providing additional larval hosts and references to the literature on this subject.

#### DISCUSSION

Of the four species treated here, specimens in reasonably good condition can be separated by features of the interfascial spot. In *E. scudderiana* it is white and stops just short of the costa. Its large bulletlike shape is distinctive, but in lighter colored specimens its distal edge is often poorly defined. *Epiblema infelix* has a white, roughly triangular interfascial spot, the anterior vertex of which extends about two-thirds the distance from the dorsal margin to the costa. The color and shape of the spot in *E. tripartitana* and *E. glenni* are discussed in the diagnosis section under *glenni*.

The dark form of *E. scudderiana* from Florida has a prominent blue-gray band that extends nearly from the costa to the dorsal margin along the distal edge of the interfascial spot. In specimens from the upper Midwest this band is not so well defined and is often broken by white coloration protruding from the interfascial spot. Intermediate expressions of this band were found in material from various localities. In *E. tripartitana* and *E. glenni* this feature is reduced to a short blue-gray dash above the fold and, in some instances, another disjoint blue-gray spot nearer the costa. *Epiblema infelix* exhibits varying amounts of gray shading beyond the interfascial spot, but the contrast with neighboring ground color is slight at best.

*Epiblema glenni* and *E. tripartitana*, though similar in both male and female genitalia, are distinct in this respect from *infelix* and *scudderiana*, as are the latter two from each other. Differences in valval shape are illustrated in Figs. 11–14. The margin of the basal opening of the sacculus in *glenni* and *tripartitana* features a basal projection below the clasper with rounded apex and sides that are roughly perpendicular. *Epiblema infelix* has no such projection, and the margin in *scudderiana* is strongly sinuate. The shape, relative size, and position of the female signa are useful diagnostic characters. In *glenni* and *tripartitana* the signa are unequal in size (Fig. 16), the larger arising near mid-bursa, the smaller near juncture with ductus bursae. In *infelix* and *scudderiana* they are roughly equal in size and



arise opposite one another at approximately mid-bursa (Figs. 17, 18).

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IMMATURE STAGES OF *ETEONA TISIPHONE* (NYMPHALIDAE: SATYRINAE)**Additional key words:** bamboo feeders, Pronophiliti, Zetheriti.

Immatures of most Neotropical Satyrinae are still poorly known or undescribed. The available information (including some partial or incomplete descriptions) includes species of rather few genera that represent only a small fraction of the main sections of this subfamily (see Singer et al. 1971, Kendall 1978, Singer et al. 1983, Young 1984, DeVries 1987, Sourakov 1996, Pelz 1997). The present paper describes the immature stages of *Eteona tisiphone* (Boisduval, 1836), a submontane Pronophiliti, in comparison with other known Satyrinae immatures.

**Study sites and methods.** Adults and immatures of *Eteona tisiphone* were studied in the field in five different localities in SE Brazil: Alto da Serra, Paranapiacaba, São Paulo (1000–1100 m); Serra do Japi, Jundiaí, São Paulo (1100–1200 m); Santa Genebra Forest Reserve, Campinas, São Paulo (600–650 m); Campos do Jordão State Park, Campos do Jordão, São Paulo (1500–2000 m); and Serra do Cristo, Poços de Caldas, Minas Gerais (1400 m). Immatures were collected in the field; eggs were also obtained from fertile females confined in a plastic bag with leaves of the host plant. Larvae were reared in plastic containers cleaned daily, with fresh plant material provided every two or three days (following Freitas 1991). Data were taken on behavior and development times for all stages, and head capsules and pupal castings were preserved. When there was sufficient material, immatures were fixed in Kahle (AVLF collection). Nomenclature follows Miller (1968) modified by Harvey (1991), who treated the group as a subfamily, and downranked Miller's subfamilies and tribes to tribes and subtribes, respectively.

**Host plants oviposition, and immature behaviors.** The host plants of *Eteona tisiphone* are bamboo species in the genus *Chusquea* (in mountain sites) and *Merostachys* (only in Campinas). Oviposition was observed many times in all study sites.

Females usually lay eggs near midday, when the temperature is high. Eggs are laid singly on the shoot tips of growing stems of bamboos, independent of their height above the ground (observed from 1 to 6 m high). Eggs are usually laid on young branches without leaves; the larva would then feed on the newly sprouting young leaves. The female lands on the tip of the stem and touches the tip of

her abdomen near a bamboo node (with or without new leaves) until she finds a suitable place to lay an egg. This process is repeated another 4 to 6 times, after which the female rests for some time before laying additional eggs or moving to another bamboo patch.

The young larva eats part of the egg chorion, and after some time starts to feed on the new bamboo leaves. The larva rests along a bamboo leaf with the head usually towards the leaf apex, being perfectly hidden and difficult to locate in the field. The larva is very active when touched and usually wanders a lot when confined in small dishes.

**Description of early stages.** The following descriptions are based on material reared from the Serra do Japi. All features of the immatures are very similar in all additional locations.

**Egg** (Fig. 1a). Spherical, slightly truncated at base, with very fine reticulations (similar to minute pits when subjected to cross-lighting); light yellow, becoming more reddish with a dark cap (head capsule of growing larva) near eclosion. Height 1.26 mm, diameter 1.14 mm. Duration: 6 days ( $n = 6$ ).

**First instar** (Figs. 1b, 2). Head capsule dark brown, with a pair of short scoli on vertex, and six pairs of regularly spaced spatulate setae. Head capsule width 0.80–0.86 mm ( $n = 4$ ); head scoli 0.14–0.12 mm ( $n = 4$ ). Body beige (light green after feeding), smooth, with many poorly visible red longitudinal stripes, and a pair of short caudal filaments. Body chaetotaxy illustrated in Fig. 2. Maximum length 7 mm. Duration: 4–5 days.

**Second instar.** Head dark brown with light frons and two dark brown diverging scoli on vertex. Head capsule width 1.02–1.08 mm ( $n = 3$ ); scoli 0.84–0.90 mm ( $n = 3$ ). Body slender, light green with many longitudinal white stripes; caudal projections short. Maximum length 12 mm. Duration: 4–6 days.

**Third instar** (Fig. 1c). Head the same as in previous instar. Head capsule width 1.36–1.50 mm ( $n = 4$ ); scoli 1.60–1.80 mm ( $n = 4$ ). Body dark green with a broad lateral longitudinal white stripe and many additional narrow light stripes; caudal projections medium long (similar to head scoli). Maximum length 16 mm. Duration: 4–5 days.

**Fourth instar** (Fig. 1d). Very similar to third instar,



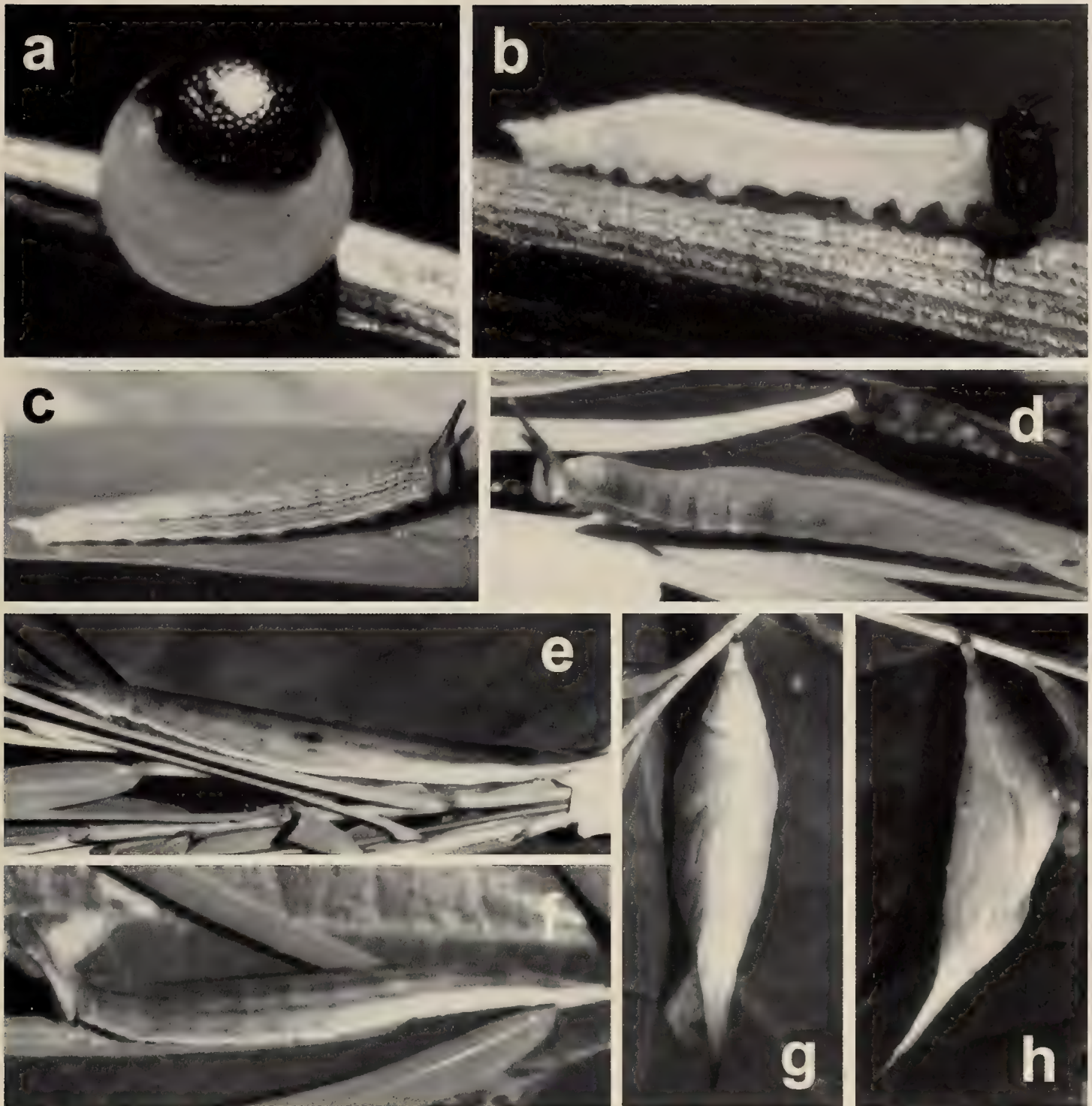


FIG. 1. Early stages of *Eteona tisiphone*. **a**, egg; **b**, first instar; **c**, third instar; **d**, fourth instar; **e**, **f**, fifth instar; **g**, **h**, pupa (ventral, lateral).

with patterns in general darker than in previous instars. Head capsule width 1.80–2.04 mm ( $n = 4$ ); scoli 2.34–3.00 mm ( $n = 4$ ). Maximum length 27 mm. Duration: 4–5 days.

**Fifth instar** (Fig. 1e–f). Head light brown with lateral area dark; a pair of long normally slightly diverging scoli (convergent in one of two individuals from Paranapiacaba). Head capsule width 2.73–2.77 mm ( $n = 3$ ); scoli 3.74–3.90 mm ( $n = 3$ ). Body slender, dark green; a conspicuous lateral longitudinal white stripe broadening towards the abdomen and many additional

narrow dark stripes; caudal projections medium long. Maximum length 40 mm. Duration: 9–10 days.

**Pupa** (Fig. 1g–h). Elongated, smooth, with long pointed ocular caps; light green with many whitish areas. Total length 25 mm. Duration 9 days.

**Discussion.** Although it is widely accepted that *Eteona* is a genus belonging to the Neotropical subtribe Pronophilini (Miller 1968, Brown 1992), its immatures diverge greatly from all known Pronophilini, whose larvae have short diverging horns and a short bifid tail, and whose pupae are short and stubby with



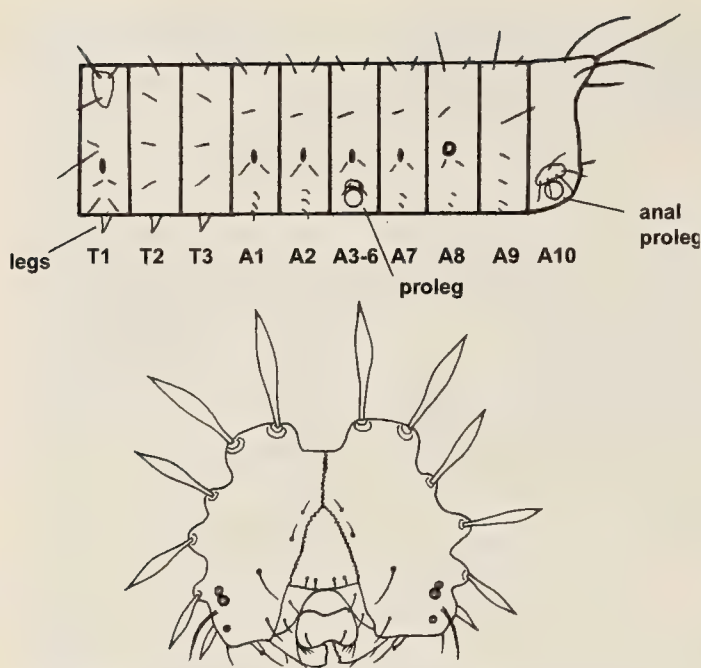


FIG. 2. Chaetotaxy (upper) and head capsule (front view) (lower) of the first instar larva of *Eteona tisiphone*.

short ocular caps (DeVries 1987, Sourakov 1996, Pelz 1997). In contrast to other Pronophilini, the larvae of *Eteona* have a pair of long horns and a medium bifid tail, and the pupa is slender with long ocular caps. This makes *Eteona* different from most Neotropical Satyrinae (Singer et al. 1983, DeVries 1987, AVL F unpublished data from 59 species), except perhaps some *Splendeptychia* (also a bamboo feeder) that also have elongated larvae and pupae (AVL F unpublished). Comparison of these immatures with the described immatures of *Zethera* (Wolfe 1996), *Penthema*, and *Neorina* (Elymniini, Zetheriti) (Lee & Chang 1988, Li & Zhu 1992, Lee & Wang 1995, Wolfe 1996) shows surprising similarities (especially in the individuals with converging head scoli), except in the first instar head capsule (smooth and without scoli in the known Zetheriti). This similarity could be due to camouflage among bamboo leaves, a feature present also in the Zetheriti and also in *Splendeptychia*. However, the simple fact of being a bamboo feeder does not necessarily lead to an elongated larva and pupa, as confirmed by the rearing of other species of *Splendeptychia*, and also *Forsterinaria*, *Carminda*, *Moneptychia* and *Pedalioides* (AVL F unpublished).

In sum, the immatures of *E. tisiphone* are highly divergent from other known Pronophilini and suggest that the taxonomic position of this genus should be verified. Any additional information from early stages of Pronophilini will be valuable to help to understand this group and the relationships within the Satyrinae.

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## NOTES ON THE LARVAL DIET OF THE PAINTED LICHEN MOTH *HYPOPREPIA FUCOSA* HÜBNER (ARCTIIDAE: LITHOSIINAE)

**Additional key words:** *Trentepohlia*, *Cladonia polycarpoides*, *Physcia millegrana*, algal partners, algivory.

It is well known that the caterpillars of the subfamily Lithosiinae (Arctiidae), or lichen moths, feed on lichens. They are suspected of being primarily algivores, feeding on algae, either free-living, or as a lichen symbiont (T. McCabe pers. com., Rawlins 1984 and pers. com.). For most species, even the most basic information on the larval diet is lacking or is poorly documented (N. Jacobson pers. com., P. Opler pers. com., J. Rawlins 1984 and pers. com.). Reports of food sources for this subfamily consist primarily of generalizations such as “lichens,” “algae,” “mosses,” or the plants that the larvae were observed on (Tietz 1952, 1972, Forbes 1954, Covell 1984, Rawlins 1984, McCabe 1991, Wagner et al. 1997, Robinson et al. 2001, D. Schweitzer pers. com.). Identification of host taxa species, or even to genus, is rarely reported. In this note we describe our observations of feeding by *Hypoprepia fucosa* Hübner and identify an algal host and two lichens ingested in captivity. We also identify the algal partners of the lichens. We are aware of only one other unpublished account that identifies a specific lichen or algal host for this species: a report by T. McCabe (pers. com.) of *H. fucosa* feeding on the free-living algae *Prototheca viridis* C. A. Agardh.

On 10 July 2001 we observed *H. fucosa* feeding on a free-living alga in the genus *Trentepohlia*. The species could not be determined with confidence, but may have been *T. aurea* Mart. given the strong orange pigmentation (P. DePriest pers. com.). The alga was growing on a concrete fireplace at a campsite located in a mature mixed-oak forest, Plumstead Township, Bucks County, Pennsylvania. The forest canopy consisted of white oak (*Quercus alba* L.), red oak (*Quercus rubra* L.), sugar maple (*Acer saccharum* Marsh.) and chestnut oak (*Quercus prinus* L.). The caterpillar was observed feeding on the algae for about one hour beginning at 2130 h before it and the alga was collected for subsequent identification.

The caterpillar was first observed about one hour after torrential rainfall associated with strong thunderstorms had passed through the area. The temperature was near 24°C and the air was humid. The caterpillar was contained within a small glass jar with no available food source for approximately 24 hours, then transferred to a small plastic insect cage lined with a 0.4 cm deep layer of garden soil. The caterpillar was then supplied with two lichens obtained from

the trunks of a red maple (*Acer rubrum* L.) and a red oak from a suburban yard in East Brunswick, Middlesex County, New Jersey. The caterpillar readily accepted these food sources and fed on both intermittently for the next three days before succumbing to a braconid wasp parasite (D. Wagner pers. com.). No preference for either lichen was apparent. The lichen collected on the red maple was *Cladonia polycarpoides* Nyl. and the lichen from the red oak was *Physcia millegrana* Degel. Algal partners of *C. polycarpoides* are from the *Trebouxia irregularis* (Hildreth et Ahmadjian) group (*T. irregularis*, *T. glomerata*, *T. pyriformis*, *T. excentrica*, *T. magna*), and for *P. millegrana*, from the *Trebouxia impressa* (Ahmadjian) Archibald group (*T. impressa*, *T. gelatinosa*) (P. DePriest pers. com.).

While feeding on the algal host and the lichens in captivity, the caterpillar used a scraping motion that may have gleaned algae from the substrate or removed the fungal component to obtain the lichen cortex with algae (J. Rawlins pers. com.). Rawlins (pers. com.) and McCabe (pers. com.) have suggested that *H. fucosa* and many other lithosiines are algal feeders, and Rawlins (pers. com.) has successfully reared more than 40 species of lithosiines from more than 20 genera worldwide on free algae growing on bark, twigs, and leaves of woody plants, often intermixed with lichens, small fungi, sooty molds, and mosses. Many reports of lithosiines feeding on lichens, mosses, or other substrates may be incidental to ingestion of algae growing mixed with these materials (McCabe 1991 and pers. com., J. Rawlins pers. com.), but the relationship between many species and algivory requires additional investigation. Our observations seem to support an algal larval diet for *H. fucosa*, and we hope add to understanding of lithosiine algivory.

We are indebted to Paula DePriest of the Smithsonian Institution for identifying the lichens and algae, to David Wagner of the University of Connecticut for assistance identifying *H. fucosa* and to John Rawlins of the Carnegie Museum of Natural History and Tim McCabe of the New York State Museum for sharing their understanding of the biology and larval diet of *H. fucosa* and other lithosiines. We are grateful to John Rawlins, Paula DePriest, Carla Penz and an anonymous reviewer for manuscript review and helpful comments. Thanks are also due to Boy Scouts of America Troop 220 for the opportunity to observe *H. fucosa* and to EcolSciences, Inc. for the time and financial resources necessary to prepare this manuscript.



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## MEGATHYMUS YUCCAE IN KENTUCKY (HESPERIIDAE, MEGATHYMINAE)

**Additional key words:** Yucca Giant-Skipper, *Yucca filamentosa*.

On 11 April 2001 the third author discovered a colony of Yucca Giant-Skippers, *Megathymus yuccae* (Boisduval & Leconte) (Megathymidae), in southeastern Calloway County, Kentucky, approximately 22 km (13.5 mi) east-south-east of Murray in the western part of the state. At least 8–10 individuals were observed, two or three of which were females, obvious because of their larger overall size and thicker abdomens. Males were observed flying about in pursuit of one another—apparently defending territories—and perching on the ground and vegetation. One male specimen was collected and photos were taken of several individuals, including a mating pair. A second mated pair also was observed, and on one occasion three males were observed simultaneously in pursuit of a single female.

The Yucca Giant-Skippers were found amidst a



FIG. 1. Yucca Giant-Skipper, *Megathymus yuccae*, Calloway Co., Kentucky, 13 April 2001; photo by Loran D. Gibson.



FIG. 2. Underside of the Yucca Giant-Skipper, *Megathymus yuccae*, Calloway Co., Kentucky, 13 April 2001; photo by Loran D. Gibson.





FIG. 3. Yucca Giant-Skipper food plant, *Yucca filamentosa* L., with larval "chimney," Calloway Co., Kentucky, 18 April 2002; photo by W. R. Black, Jr.

colony of Yucca, *Yucca filamentosa* L. (Liliaceae), consisting of approximately two or three dozen plants scattered along the shoulders of a gravel road. The site extended for approximately 245 m (200 yards) and was situated on a ridgetop of dry, gravelly soils. The surrounding vegetation consisted primarily of relatively young, second-growth upland oak-hickory forest. There were also numerous Loblolly pines, *Pinus taeda* L. (Pinaceae), a species not native to Kentucky, scattered throughout the forest and roadside. The roadside shoulders were vegetated with young trees, shrubs and weeds, providing a more open habitat for the yucca plants to grow and spread. The senior author was notified of the find, and he was able to relate the fact that characteristic larval "frass chimneys" should be present within nearby yucca plants if the skippers had been established at the site prior to the observation. Subsequently, three such structures were located in yucca plants along the roadside. Later that day, the senior author confirmed the identification and pre-

pared the collected specimen, which serves as a voucher for not only a new Kentucky record, but also a north-central extension of the known range of *M. yuccae*.

On 13 April 2002 the second author and Loran D. Gibson visited the site. Gibson reported "20 to 25 of the skippers flying about and easy to approach." More photos of the food plants and skippers were taken (Figs. 1, 2). The third author returned to the site on 26 April 2002 and found three individuals still present. One was a female that appeared to be searching for host plants on which to lay eggs. The other two were males, one being very worn.

On 18 April 2002, the second author visited the site again, and observed a fresh female ovipositing on a yucca plant, and eggs on the plant. A male and another individual, quite worn, were observed at this site. He drove along several roads in the area and found four additional sites with evidence of *M. yuccae*'s presence. At one, there was an unopened larval "chimney" associated with a Yucca plant (Fig. 3). At the second, he



found one live pupa in a broken-off "chimney," and one female ovipositing on different plants. At a third site he observed three unopened "chimneys," plus 10 eggs on yucca leaves. At the final site he found two "chimneys." All sites are within a few miles of each other in Calloway County, Kentucky.

The Yucca Giant-Skipper has not been published as occurring in Illinois (U.S.G.S. state lists) or Missouri (J. R. Heitzman pers. com.). Leroy C. Koehn (pers. com.) reported that he has found colonies in western Tennessee, but these data have not been formally published.

These colonies represent the northern-most known occurrence of a breeding colony of *M. yuccae* along the Mississippi River. On the East Coast it extends northward to southeastern Virginia at about the same latitude as the Calloway County site; and farther west it is found in Kansas and westward also at about the same latitude (Opler & Malikul 1998).

Interestingly, Yucca has been so widely introduced and adventive populations have spread so readily beyond its historic range that it is not completely clear how far north natural populations of this plant occur (J. N. N. Campbell pers. com.). According to Medley (1993), the species is not native to Kentucky. However, with populations of the plant seemingly well estab-

lished, it appears that the Yucca Giant-Skipper may now be established along with its host plant. These small colonies are vulnerable to habitat destruction, over collecting and other dangers. We hope to investigate protection of these sites and to seek other colonies in the area.

We thank Loran D. Gibson for the use of his photographs of the live Yucca Giant Skipper.

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### FEMALE NORTH AMERICAN *EVERES* HÜBNER, [1819] AND THE IDENTITY OF *LYCAENA* SISSONA W. G. WRIGHT, 1905 (LYCAENIDAE)

**Additional key words:** genitalia, identification, subspecies.

Two similar species, *Everes amyntula* (Boisduval, 1852) and *Everes comyntas* (Godart, [1824]) (Lycaenidae: Polyommatainae), are broadly sympatric and may fly together in parts of the western United States and adjacent Canada (Scott 1986, Stanford & Opler 1993, Layberry et al. 1998, Guppy & Shepard 2001). The former is widespread while *E. comyntas* apparently occurs in scattered populations west of the Rocky Mountains, but, at times, the latter may be the only or most abundant species at some locales. Although a number of wing traits have been implicated as useful in separating these species (e.g., Klots 1951, Downey 1975, Fisher 1981, Pyle 1981, Opler 1999), individual, seasonal, and geographical variation confound their identity. This variation has not been thoroughly investigated and it may be that superficial differences will have to be elaborated at the local level. Males have

demonstratively different genitalia, most readily seen in the shape of the uncus (Bethune-Baker 1913, Johnson 1972, Dornfeld 1980, Fisher 1981, Scott 1986, Guppy & Shepard 2001). Females generally have not been distinguished except by association with males and superficial characters of apparently limited value. One character that has not been mentioned, but may be useful in separating females of the two species, is in the submargin of the dorsal hindwing. All female *E. amyntula* examined from Arizona, California, Colorado, Nevada, Oregon, and Utah (n = 265) had a row of usually several pale submarginal macules. *Everes comyntas* from Arizona and California (n = 54), however, lacks these macules except on apparent short-day phenotypes having considerable dorsal blue (e.g., Field 1938, Shapiro 1974a). It thus seems that individuals without pale submarginal macules on the dorsal

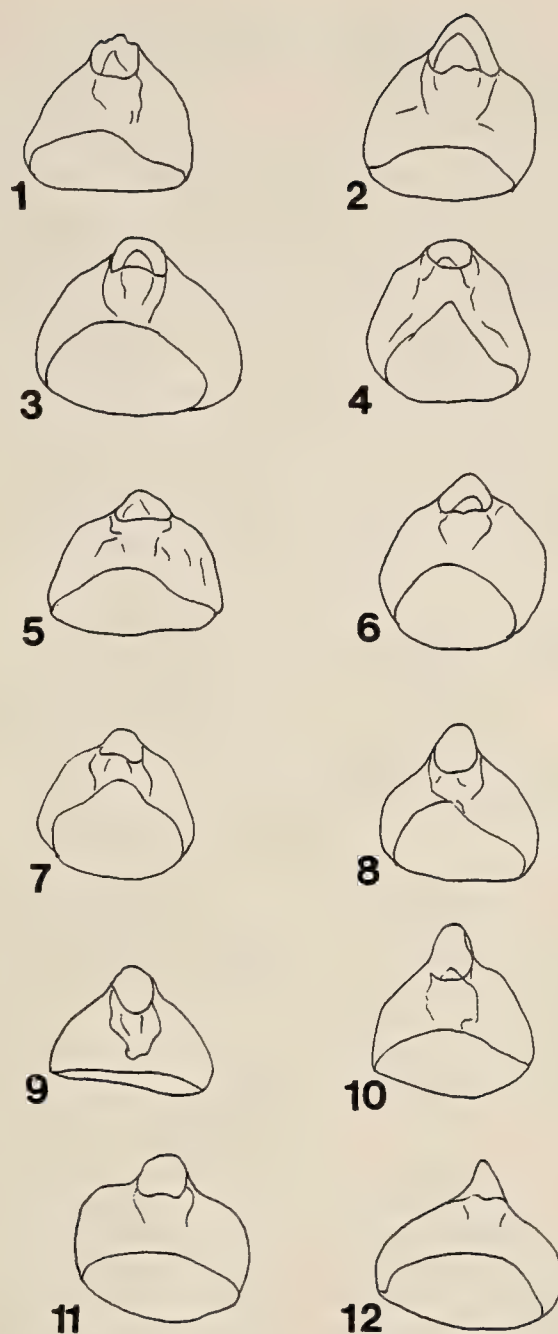


hindwing are *E. comyntas*; those with macules could be either species (e.g., see Howe 1975, wherein all three possibilities are illustrated). Over 100 female *Everes* (76 *E. amyntula*, 42 *E. comyntas*) from the United States and northern Mexico have been dissected and a difference was detected between the genitalia of taxa commonly placed within *E. comyntas* and *E. amyntula*. The genital plate (sterigma) of *E. comyntas* is small and rounded (Figs. 1–12), while that of *E. amyntula* is comparatively larger, more triangular, and some (Figs. 17, 18, 21, 22) exhibit a notch at its posterior edge (Figs. 13–24). These exhibit some variation within both species, locally (e.g., Figs 1–4; 19–22) and perhaps geographically, but their overall gestalt remains, including that of an *E. comyntas* from Veracruz, Mexico.

Wright (1905) illustrated, named, and briefly described *Lycaena sissona* based upon a single female from "Sisson, Cal." (now the city of Mt. Shasta);. The holotype, spread with the ventral surface upward and housed at the California Academy of Sciences (Tilden 1975), has the following labels: small, white, handwritten - / 400 /; red, printed - / HOLOTYPE ♀ / *Lycaena* / *sissona* Wright / Det. J. W. Tilden 1975 /; white, printed and handwritten - / W. G. WRIGHT / Plesio-type No. 400 / Illustrated in his / *Butterflies of the West Coast* / Calif. Acad. Sci. Coll. /; white, printed and handwritten - / California Academy / of Sciences / Type / No. 4319 /; white, printed and handwritten - / Genitalic Vial / GTA - 12243 /. The specimen appears to be in the same condition as when it was originally photographed (Wright 1905).

*Lycaena sissona* has largely been treated as a synonym of *Everes comyntas comyntas* (Comstock 1927, McDunnough 1938, dos Passos 1964, Miller & Brown 1981, 1983), but was placed as a synonym of *E. amyntula amyntula* "based upon Wright's illustration" by Ferris (1989). As far as can be determined, the type has not heretofore been critically examined. Wright's (1905) illustration is of the ventral surface and, as noted above, the only potentially useful characteristic to separate females of the two species is on the dorsal hindwing. The dorsal surface of the type is uniformly brown except for a vague orange macule proximad to a vague black marginal spot in hindwing cell  $CuA_1$ – $CuA_2$ . The absence of submarginal macules and the configuration of its genital plate (Fig. 6) clearly identifies the specimen as an *E. comyntas*.

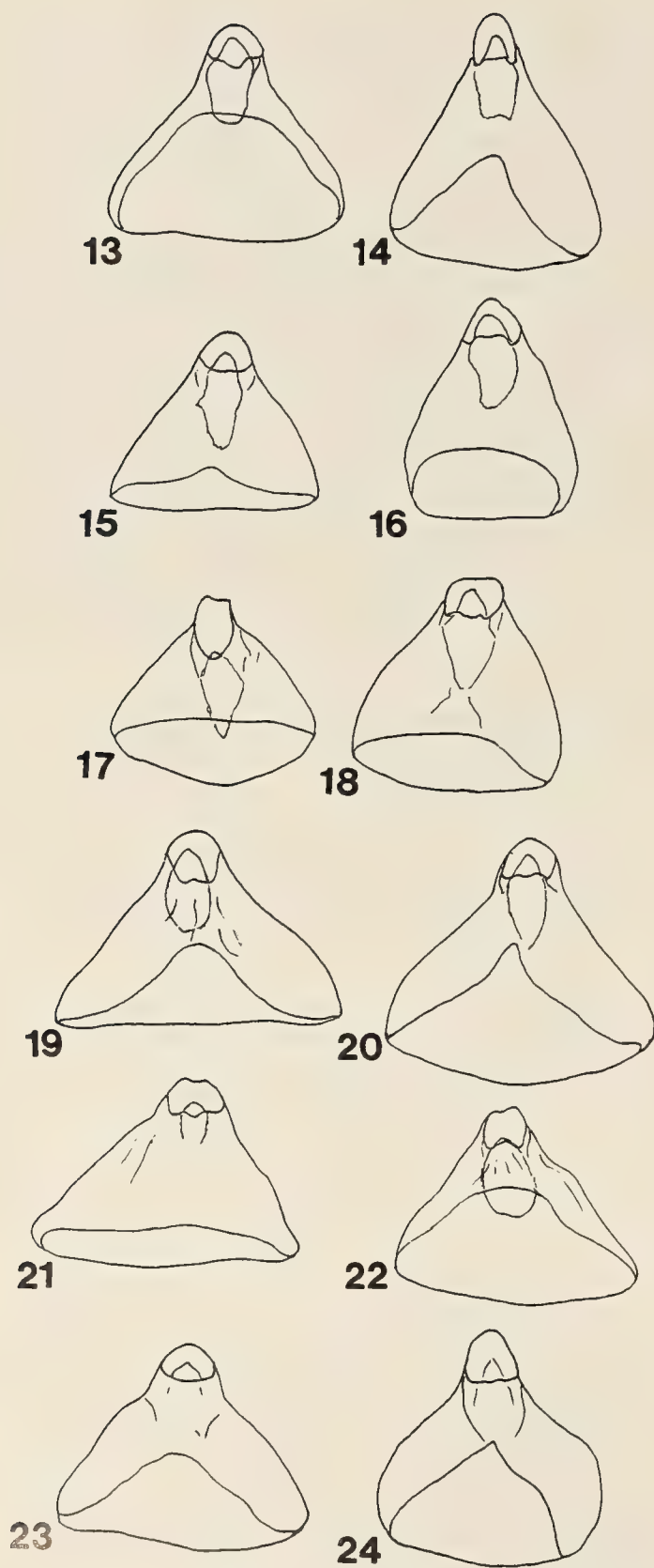
Western *E. comyntas*, specifically those in California, have not been elaborated. Dornfeld (1980), Emmel et al. (1998), and Guppy and Shepard (2001) have all considered *E. comyntas comyntas* to embrace populations in the western United States and south-



FIGS. 1–12. Dorsal view of the genital plate of female *Everes comyntas* (numbers following data are GTA genitalic vial numbers). 1–4. CA: Sutter Co.; Sutter bypass, Hwy. 20, E of Meridian, 29 May 1989 (11541, 11542, 11543, 11221), 5. CA: Colusa Co.; Ca 20 at Ca 45, W of Meridian, 29 May 1989 (11544), 6. holotype of *Lycaena sissona* (12243), 7. CT: Hartford Co.; New Britain (7129), 8. MS: Natchez Trace, 8 mi. S of Tupelo, 13 June 1972 (7139), 9. MN: Itasca Co.; Deer River, 29 June 1971 (7130), 10. WI: Iron Co.; Rt. 2, 29 June 1971 (11219), 11. AZ: Santa Cruz Co.; Sycamore Canyon, 22 June 1983 (11551), 12. AZ: Santa Cruz Co.; Sycamore Canyon, 9 July 1980 (11552).

western Canada. These have a paler and grayer venter than that of populations from the eastern United States and thus the white halos around the black discal macules are less distinct. The submarginal row of macules on the ventral forewing is less complete and less well-defined on individuals from California as are the





FIGS. 13–24. Dorsal view of the genital plate of female *Everes amyntula* (numbers following data are GTA genitalic vial numbers). 13. NV: Mineral Co.; White Mts., road to Sugarloaf, 5.1 mi. S of Montgomery Pass, 1 July 1991 (11212), 14. NV: Nye Co.; Toiyabe Mts., Jett Canyon, 17 May 1990 (7142), 15. NV: Clark Co.; Moapa Valley, California Wash, 18 June 2000 (11181), 16. CA: Nevada Co.; S Fork of Yuba River, N of Nevada City, 13 May 1985 (11546), 17. CO: Garfield Co.; White River Plateau, Coffee Pot Springs, 10100', 27 June 1963 (11353), 18. NV: Elko Co.; Jarbidge Mts., Bear Creek

marginal macules on the ventral hindwing. Also on the ventral hindwing, the orange macule or macules towards the tornus are notably paler in California, not bright orange. These characters conform with the holotype of *Lycaena sissona* and indicate that populations in California and perhaps elsewhere in western North America should be treated as a recognizable subspecies, *Everes comyntas sissona* (W. G. Wright, 1905), **new combination**.

In comparison with Californian populations of *E. amyntula amyntula*, *E. comyntas sissona* has a more rounded forewing termen (this appears as a useful character throughout the distribution of both species, contra Downey 1975), has less dorsal blue (usually without, except on the short-day form), the ventral hindwing orange is usually more prominent, and the ventral forewing macules are usually further from the submarginal macules and form a straighter row (usually more sinuate on *E. amyntula*). The male has a broader black margin on the dorsal forewing (usually very thin on *E. amyntula*) and usually has at least one orange macule on the dorsal hindwing (usually absent on *E. amyntula*). The female of *E. comyntas* has no submarginal pattern on the dorsal hindwing (again, except on the short-day form); these are nearly always prominent on *E. amyntula*. Most male *E. comyntas* from throughout the species' distribution have a thin line of black scales at the distal end of the forewing discal cell whereas this was not seen on examined *E. amyntula*. Females of both species often have a similar and sometimes broader black mark in the discal cell. This is most readily seen on extensively blue individuals.

In California, *E. comyntas* apparently mostly inhabits lowlands, frequently along ditches and other waterways (Opler & Langston 1968, Shapiro 1974a, 1974b, but see Garth & Tilden 1963); *E. amyntula* is largely montane (Comstock 1927, Emmel & Emmel 1962, Shapiro et al. 1979). In Oregon, the two species fly sympatrically and synchronically at several sites in the Coast Range (fide A. D. Warren). *Everes comyntas* has a long flight season and may have two to five broods annually (Opler & Langston 1968, Shapiro 1974a) whereas *E. amyntula* are apparently univoltine or bi-

←

Summit, 7 Aug. 1980 (7160), 19. NV: White Pine Co.; Schell Creek Range, Timber Creek, 5.6 mi. E of Nv 486, 15 July 1981 (7157), 20. NV: White Pine Co.; Schell Creek Range, Berry Creek, 2.3–5 mi. E of Nv 486, 16 July 1981 (11555), 21. NV: White Pine Co.; Snake Range, Baker Creek Campground, 16 July 1980 (7159), 22. NV: White Pine Co.; Steptoe Valley, Warm Springs, 24 June 1987 (7154), 23. NV: Washoe Co.; Carson Range, Tahoe Meadows, 10 July 1990 (11214), 24. NV: Carson City; Carson Range, Nv 28, 2.0 mi. S of Washoe Co. line, 1 July 1985 (7128).



voltine (Emmel & Emmel 1962, 1973, Shapiro et al. 1979). Both species use a variety of legumes (Fabaceae) as larval hostplants (Emmel & Emmel 1962, 1973, Shapiro 1974a, 1974b, Shapiro et al. 1979), including alien taxa (Shapiro 2002). Whether there are any hostplant preferences for either species, except those imposed ecologically, has not been reported in California. In Colorado, *E. comyntas* uses larval hostplants occupying more mesic sites than those of *E. amyntula* (Scott 1992).

I thank Norman D. Penny at the California Academy of Sciences for loaning and permitting dissection of the type of *Lycaena sissona*. Chuck Hageman and Sterling O. Mattoon graciously led me to populations of *E. comyntas* in California and allowed examination of specimens in their collections. Andrew D. Warren read a draft of the manuscript and made useful comments.

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## ERRATA

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### EMERGENCE OF PARASITIC FLIES FROM ADULT *ACTINOTE DICEUS* (NYMPHALIDAE: ACRAEINAE) IN ECUADOR

In the above article by Harold. F. Greeney and John O. Stireman (*Journal of the Lepidopterists' Society* 55(2):79–80), the genus name of a parasitic fly was misspelled. Where it reads “*Arachidomya* sp.” (pp 79 and 80) it should read “*Arachnidomya* sp.”











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